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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See page 15, Sept. 10. 8421

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See Advt. Page 132, Sept. 10.

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MOURNE SCHEME.

CONTRACT A.

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The Belfast City and District Water Commissioners are prepared to receive

Tenders from Competent

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The Contract Drawings and Specification have been prepared by the Commissioners' Chief Engineer, Mr. F. W. M'Cullough, M.Inst.C.E., Water Office, Royal Avenue, Belfast, and may be inspected at his Office on any weekday (except Saturday), between the hours of Ten a.m. and Five p.m.

Duplicate Copies of the Specification and Form of Tender, &c., may be obtained from the undersigned upon payment of the sum of Five Guineas. This sum will only be repaid by the Commissioners after the receipt of a *bona fide* Tender which has not been withdrawn.

On the Tuesday and Friday of each week, commencing with Tuesday, the 28th inst., an Assistant Engineer will meet intending Contractors at the Engineer's Office, at Ten o'clock forenoon, and accompany them to the site of the proposed Works.

Tenders, sealed and endorsed "Tender for Silent Valley Storage Reservoir, &c.," must be delivered by registered post, and addressed to the undersigned, not later than Three p.m. on Wednesday, 3rd November, 1920.

The Commissioners do not bind themselves to accept the lowest or any Tender, nor will they be responsible for any expenses incurred in making out a Tender.

W. I. QUINN, Secretary, Water Office, Royal Avenue, 9th September, 1920. Belfast. J 787

TO CONTRACTORS.

BELFAST WATER WORKS.

MOURNE SCHEME.

CONTRACT A.

For the Construction of the "SILENT VALLEY" STORAGE RESERVOIR, &c.

SCHEDULE OF QUANTITIES.

A Detailed "Schedule of

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ACHESON FERGUSON, Quantity Surveyor, Scottish Provident Buildings, 9th September, 1920. Belfast. J 788

G. R.

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J. J. BREWER, Secretary.

London Bridge Terminus, S.E. 1, 10th September, 1920. J 739

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B. T. HAWKINS, Borough Electrical Engineer. J 660

COUNTY BOROUGH OF ST. HELENS.

ELECTRICITY DEPARTMENT.

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Particulars of same may be had from drawings to be obtained from the undersigned.

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B. T. HAWKINS, Borough Electrical Engineer, St. Helens. J 661

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DEPARTMENT OF ENGINEERING.

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HERBERT REED, Chief Education Officer.

Education Offices, 16, John Street, Sunderland. 7th September, 1920. J 699

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ENGINEERING DIVISION.

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Particulars of the conditions of service will be found on the Form of Application, which may be obtained at the office of the Chief Engineer, 109, Leadenhall Street, E.C., to whom all applications must be addressed and delivered not later than Noon on Monday, 4th October, 1920.

C. R. S. KIRKPATRICK, M.Inst.C.E., Chief Engineer.

31st August, 1920. 109, Leadenhall Street, E.C. 3. J 585

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6th September, 1920. J 608

DUDLEY EDUCATION COMMITTEE.

DUDLEY TECHNICAL SCHOOL.

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Candidates must possess good practical experience and either a University degree or Academic qualifications of approved standard in mechanical engineering.

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J. WHALEY, Director of Education.

St. James' Road, Dudley. J 802

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The TECHNICAL INSTRUCTION COMMITTEE invite

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TWO LECTURERS in ELECTRICAL ENGINEERING. Remuneration for each Lecturer, £383 17s. 6d. per annum including bonus, rising to £456 7s. 6d. per annum.

Particulars of the Duties and Conditions of Appointment may be obtained from the undersigned, with whom applications, on the special Form provided for the purpose, must be lodged not later than noon on TUESDAY, 21st September, 1920.

Applications should be accompanied by three recent testimonials (original testimonials must not be sent).

Canvassing is strictly forbidden and will disqualify.

RUPERT STANLEY, Principal, Municipal Technical Institute, Belfast. J 733

ROYAL NAVAL COLLEGE, GREENWICH.

Applications are Invited

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INSTRUCTOR IN MATHEMATICS.

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DEMONSTRATOR IN APPLIED MECHANICS. Salary £300, rising to £350 by annual increments of £20.

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KENT EDUCATION COMMITTEE.

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Applications are Invited for

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Forms of application can be obtained from Mr. A. H. BELL, Technical Institute, Sheerness, to whom they should be returned immediately.

E. SALTER DAVIES, Director of Education.

14th September, 1920. J 804

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

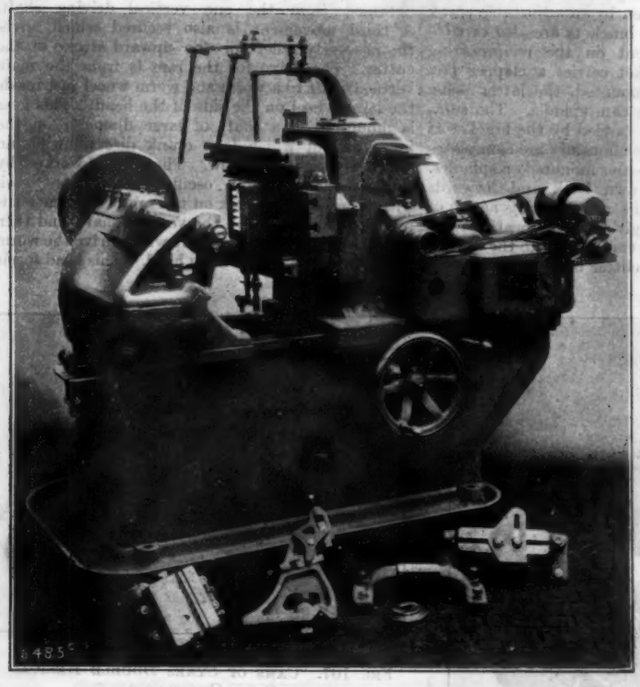
(*Continued from page* 341.)

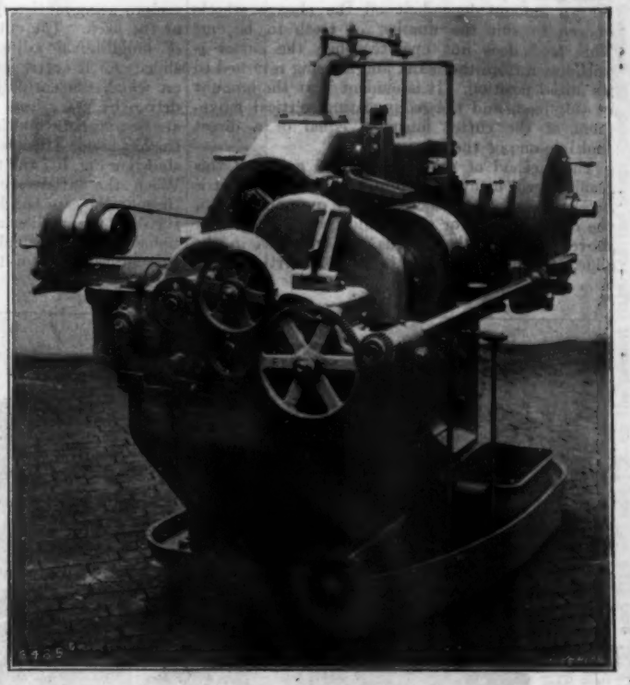
IN continuing our description of machines at the Machine Tool and Engineering Exhibition, having dealt at considerable length with the class of tools used in general manufacturing, we propose to devote some attention to a few of the more specialised classes, and commence with gear generating machines. These we shall follow with relieving lathes and precision screw lathes. In this connection we shall also take a few examples of gauge and gear measuring machines.

GEAR GENERATING MACHINES.

As is well known the "Sunderland" gear planer developed by Messrs. J. Parkinson and Son, Shipley, is of the class using a rack tooth cutter, the cutter and blank to be cut moving in unison to reproduce the rolling motion of a spur wheel in mesh with a rack. We described an earlier model of this machine in 1917 (*vide* ENGINEERING, vol. civ, page 617). The present machine, as shown in the example on view at the Machine Tool Exhibition, embodies many fundamental changes.

Fig. 103 subjoined shows clearly the cutter slide mounted on the main head, and also the mandrel, at the left-hand end, on which the work is mounted, as well as the master worm wheel, encased in a cover. In Fig. 104, which gives a view of the other side of the machine, this worm wheel will be seen to be driven by a worm and shaft receiving a feed motion which is intermittent from change wheels selected according to the number of teeth to be cut. The rack form cutter is given a reciprocating movement across the blank, and between successive cuts is given a downward feed, the blank being revolved in the same sense. At the end of a vertical travel equivalent to one pitch the cutter is withdrawn by the whole head carrying the slide moving away from the blank. While thus freed the vertical movement of the cutter is reversed, and it is moved upwards a distance equal to one pitch when the head is brought forward again, and the cutter recommences work one pitch further on on the blank. The main drive to the spindle producing the reciprocating movement of the shaping cutter is comparatively simple. The main pulleys will be seen in Fig. 104, the change wheels being enclosed in a cover on the near side of them. The cutter stroke can be varied and is easily set by clamping a nut in position in a circular slot.





FIGS. 103 AND 104. SUNDERLAND GEAR PLANER; MESSRS. J. PARKINSON AND SONS.

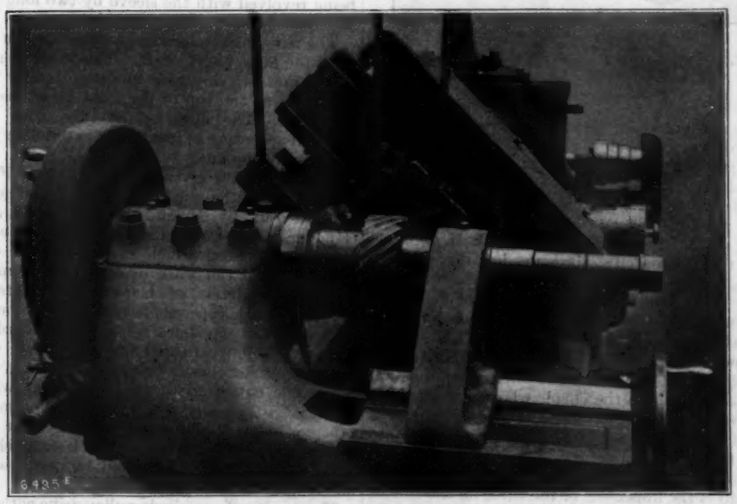


FIG. 105. SUNDERLAND GEAR PLANER SLIDE SET FOR HELICAL GEARS.

The manner in which the other movements are attained are more interesting. In the first place we will deal with the vertical feed to the slide. This motion is at one speed for the downward stroke, and at a quicker speed for the upward movement. Both are run on one shaft, which for convenience we will distinguish as A, by ratchets, the slow speed being overtaken by the other when the latter is brought into action. Whichever of the two speeds is engaged the drive is by gear wheel to a larger wheel carried on a sleeve, on a shaft B, this shaft being driven from this wheel through what is virtually back gearing mounted on a shaft C. The large wheel to which we now refer is of peculiar construction. It has one complete ring of teeth, and in addition two partially complete rings, the remaining positions of these arcs being cut away blank. On the back shaft is a double pinion, meshing above with another double pinion. These are set to one side of each other in mesh, and their other portions gear with the partial segments of the larger wheel. The result is that while the latter revolves in one direction with its sleeve, the back shaft C, and the shaft B, are driven first in one direction and then reversed and driven in the other direction an equal distance, the relative angular movement of the large wheel and its sleeve and the shaft, B, on which it is carried, depending upon the change wheels interposed between the shafts, C and B. These wheels are chosen in accordance with the required pitch. The reversing motion thus given to the shaft C is communicated to a screw and nut driving the tool slide. The first shaft, termed A, performs another function by means of a ratchet arrangement; through mitre gears it works an eccentric

which draws back the whole head from the blank. This ratchet is only operative at one point of the cycle; at other times the pawl is held in the disengaged position. The withdrawal synchronises with the upward movement of the cutter. Again driven off the shaft C, which is the first shaft with reversing motion, is another ratchet gear which drives the master worm and the wheel on the work mandrel. This ratchet therefore feeds the blank on an amount dependent on the change wheels chosen to suit the number of teeth to be cut. This feed does not operate while the cutter is withdrawn from the blank and is being returned to its initial position. It is evident that the amount of this feed, and the reciprocating vertical movement of the cutter must be equal or a direct multiple one of the other.

The method of producing helical gears on this machine will be evident from Fig. 105. All that is necessary is to set the cutter slide over one way or the other, for left or right hand gears; the cutter moves as before backwards and forwards in the slide, and the whole slide is given a vertical feed, creeping in. The cutter movements are carried by two brackets seen on the left hand side of the backplate. Each cutter is mounted in a box, the two being seen side by side opposite the gear, being cut. The far cutter is worked by a bar controlled by the motion mounted on the left hand bracket. The near cutter is operated by a sleeve through which the bar for the other cutter head passes. The cutter heads are mounted on a large slide which is given a reciprocating motion driven by an adjustable crank at the back. The cutter brackets are also capable of longitudinal adjustment on the reciprocating slide. Each cutter bracket carries a clapper box on which the cutter is mounted, the latter being driven by gears from the cam spindle. The cams are arranged in housings carried by the bracket at the left hand. Inside these housings are cam plates shown in Fig. 107 and the cams mounted on spindles. When the latter are drawn back and forwards through the cam box by the reciprocating action of the slide, the spindles are given a reciprocating rotational movement which is transmitted to the cutters through the gears on the cutter brackets. In addition, by means of a worm index wheel the whole cam box is revolved slowly so as to provide the true rolling motion between the cutters and the work. The clapper boxes are positively tilted, and the cutters withdrawn from the work, during the return stroke, by gear driven from a cam on the crank shaft. The feed for the work is obtained from the crankshaft through belt-driven step pulleys and gears and a worm to the work indexing worm wheel on the right hand of Fig 106.

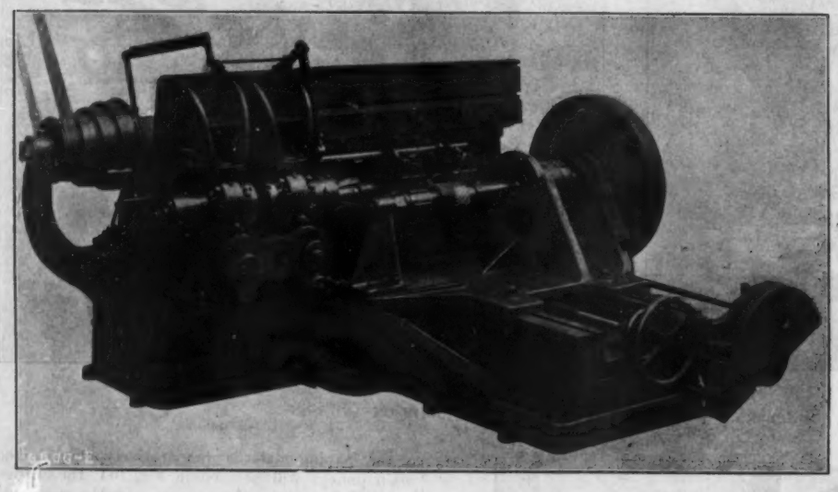


FIG. 106. SYKES DOUBLE HELICAL GEAR GENERATOR; THE POWER PLANT COMPANY, LTD.

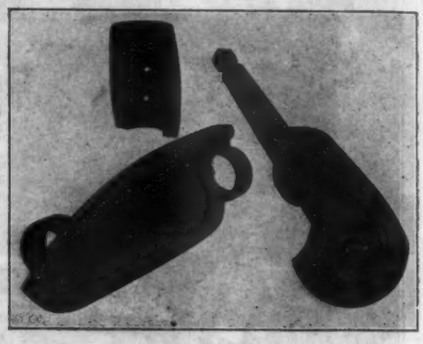


FIG. 107. CAMS OF SYKES DOUBLE HELICAL GEAR GENERATOR.

Other details of the machine well deserve mention, but we have dealt with it sufficiently fully to give an idea of the manner in which its main functions are obtained.

In 1916 (Vol. cii., p. 34) we gave a detailed description of the Sykes double helical gear cutter of the Power Plant Co., Limited, West Drayton. This was a generator for double helical teeth, employing special spur wheel cutters in rolling contact during the working stroke with the blank. The work was slowly rotated and the two cutters, also rotated, were given an alternating reciprocating motion, combined with a helical movement effected by mounting them on rifle bars. Since that date the machine, while employing the same principles, has been considerably improved, in the direction of simplification and accuracy. The latest model we hope to deal with fully on a future occasion, but we now illustrate one of the types of machine shown at the exhibition. This is shown in Fig. 106, above, while Fig. 107, annexed, gives details of the cutter cams of the machine.

This particular machine is able to cut double helical gears up to 26 in. in diameter and from 1 in. to 12 in. face width. The smallest pitch possible is 10 D.P. or $\frac{\pi}{10}$ in. circular pitch, while the largest is 2 D.P. or $1\frac{\pi}{2}$ in. circular pitch. The pitch diameter of the cutters used is 6 in. The spiral angle is 30 deg., the standard now adopted for all the Power Plant Company's work. The number of speeds provided is four, by means of the cone pulley drive. There are also four feeds, this range having proved ample. In this machine the cutter movements are both arranged on one side, and the present machine is much more compact than its predecessor, while there are less chances of inaccuracy of motion

A spur gear generator using a circular cutter is illustrated in Figs. 108 and 109, Plate XLII. This machine is by Messrs. David Brown and Sons (Huddersfield), Ltd. The work is mounted on a horizontal revolving table and the cutter which is given both a reciprocating vertical, and a revolving motion, is carried in a large head which can be traversed in to or out from the centre of the work table to deal with different sized jobs. The handwheel for traversing the head is the upper one of the three on the side of the machine shown in Fig. 109. An index scale is marked on the slide and the handwheel has micrometer adjustment. The main drive is by single pulley and a four-speed gear box shown in Fig. 108. From this box the drive is taken by a horizontal shaft to the work table through dividing change wheels, and by bevels and a vertical shaft to the cutter head. The drive is engaged by a clutch in the belt pulley, combined with a brake for quickly stopping the machine when the clutch is thrown out. The change wheels for the work table are the nearest train of wheels shown in Fig. 108 on the side of the base. The drive is through worm gearing. The table drive can be disconnected by swinging a worm in a cradle, when the table can be revolved by hand. This is performed by the hand wheel and worm shown as the nearest of the three in Fig. 109. The third handwheel is for the change of speed gear.

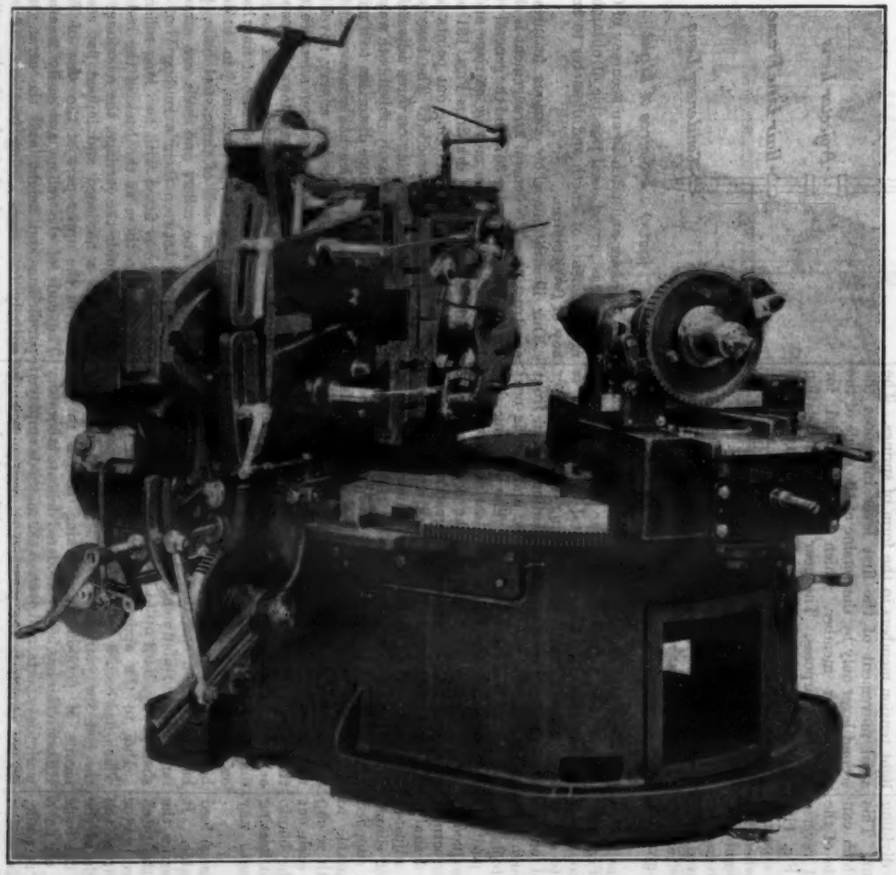
The cutter is mounted on a ram which does not revolve but is given a reciprocating vertical motion only. The cutter bar passes up through the ram, and at its upper end passes through a worm-driven sleeve which gives to it the necessary revolving motion. Both these movements are obtained from the one vertical driving shaft. A third movement is also secured which gives the necessary relief for the upward stroke of the cutter. The drive for the ram is from the main vertical shaft to a worm and worm wheel just inside the large wheel on the side of the head. This gear is mounted on a shaft of large diameter on the inner end of which is a crank disc allowing an adjustment of the throw. The ram is worked by this by means of an oscillating quadrant rack with corresponding rack on the ram. The cutter is revolved by a worm on the vertical shaft, and then by a train of feed change gears which drive the worm wheel on the cutter dividing head. This head forms a sleeve inside which the cutter bar slides, the latter being revolved with the sleeve by two long keys on the upper portion of the cutter bar.

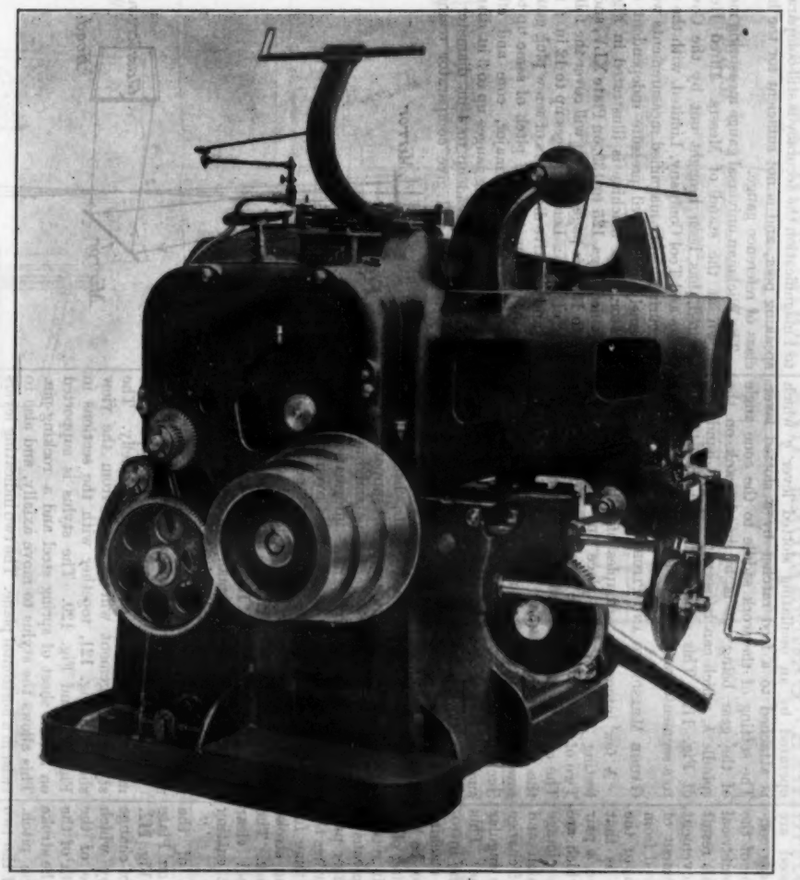
The relieving mechanism is a cam motion derived from the large crank shaft. This causes the whole of the ram carrying gear to swing slightly forward on pivots at the top of the head at set periods of the cycle. The direction of this swing can be changed according as to whether external or internal gears are being cut.

Two views are given in Fig. 110 and Fig. 111, Plate XLII of the new double helical gear generator brought out by Messrs. David Brown & Sons (Huddersfield), Limited. This machine also has a traversing head which can be moved towards or away from the work mandrel to accommodate different diameters of blanks. The cutters used are of the rack type, these tools being mounted in clapper boxes on slides set at a standard angle. The cutters move to and fro alternately, the end of their stroke always being on the same vertical line. The cutter slides are so set that when the cutters are properly fixed in them by means of tapered cotters, the front cutting edge always works up to this line, making a clean finish at the apex which cannot be affected by maladjustments on the part of the operator.

The machine has a single-pulley drive with friction clutch and four-speed gear-box. From this the drive is carried by bevels and shaft up to the top of the head of the machine. In the head is a double differential from which the drive is taken, both to the cutter slides, and to the work feed-box in the head. From the latter a shaft is run down to the horizontal shaft seen on the side of the machine in Fig. 110. Off the outer end of this shaft, through a train of change wheels and a worm, the large work dividing wheel is driven. The latter will be easily recognised in our views.

A second gear-box is arranged at the top of the head, namely for the indexing mechanism. From the double differential referred to above a vertical lead screw is driven, which controls the movement





FIGS. 117 AND 118. SPIRAL BEVEL GEAR GENERATOR; MESSRS. SMITH AND COVENTRY, LTD.

of the saddle. The saddle is fed vertically upwards during the cutting operation, and then the lead screw is reversed by trip gear, the saddle is lowered, and the necessary indexing accomplished through a distance equal to one or more pitches. While the indexing gear is in operation the work feed is stopped. During the upward or cutting stroke of the saddle the index gear is out of operation, and the work feed is engaged. The indexing is always engaged with the cutters withdrawn from the blank. The cutter slides receive their reciprocating movement on the saddle from cranks. The clapper boxes are controlled by cams which cause the cutters to withdraw from the work on the return stroke.

In Fig. 111 the hand-wheel and lever at the right-hand end of the machine are respectively for the speed-box and clutch. The other hand-wheel is for the traverse of the head. The change wheels partly enclosed in covers at the top of the head are the index gears, while those below the large dividing worm-wheel are the feed change gears. The hand-wheels seen in Fig. 110 on the outside of the dividing wheel are for the collet chuck. In Fig. 111 the machine is shown with one support for the blank removed to give a better view of the clapper boxes. There are properly two supports, one on either side of the blank. The machine will cut gears up to 36 in. diameter by 6 in. face, and up to 1 in. C.P. or 3 D.P. The head traversing hand-wheel is arranged with a micrometer collar so that the correct depth of cut may be readily procured.

Another interesting machine finding a place among the gear-cutting exhibits is the patent spiral bevel planer shown by Messrs. Smith and Coventry, Limited, of Gresley Ironworks, Manchester. Since their extensive adoption in motor-car back axles, spiral bevels have become of great commercial importance, and any mode of production or machine increasing their accuracy and facilitating their manufacture is likely to become of considerable value. The new Smith and Coventry machine would appear to fall in with these desiderata. The machine is illustrated in Figs. 112 to 116, Plate XLIII, and Figs. 117 and 118, on the present page. It will at once be evident that it is related to the well-known Rebey-Smith bevel gear planer. The mechanism of planing a tooth by two simple tools which is a feature of this latter machine is retained in the spiral bevel planer, and the necessary spiral shape is introduced into the teeth by giving the wheel which is being cut an angular movement during the passage of the cutting tools across it. The simplicity of the method and the simplicity of the tools used are not, however, the only important features of this machine. It is claimed that a spiral tooth is formed which is nearer to theoretical accuracy than has before been achieved.

The spiral bevels produced by the machine are of the same order of accuracy as modern spiral

spur gears, or as the involute curve which is used for the wheel tooth. The teeth produced are symmetrical at every section about a plane containing the axis of the gear, and the spiral of the teeth on the pitch cone is a correct geometrical figure having a uniform lead of spiral. This result is obtained by the correlation between the movement of the shaping tool and the angular movement of the blank. The angular movement is derived from the same mechanism which gives motion to the cutting tool. A further important point is that absolute correctness of engagement between a pair of wheels (a pinion and a crown wheel) which are cut on the machine, is ensured, since the change of spiral lead necessary between the pinion and crown wheel is made by means of a pair of change gears of exact ratio, and is not made by the angular setting of an adjustable part of the machine. This latter method is obviously susceptible of the introduction of inaccuracy. A feature of the machine which a little consideration will show to be an essential one, is that the cutting tools swing clear of the blank while they are making their return stroke. This operation is carried out by means of a spring which is loaded up during the latter part of the stroke. When released this spring swings the cutting tool clear, and in order to give time for the tool to move away the actual cutting stroke is carried a little beyond the edge of the blank. The same mechanism which swings the tool clear returns it to position again for the next cutting stroke.

Various illustrations showing details of the machine are given in Figs. 112 to 116, on Plate XLIII, and of these we may first refer to Fig. 112. At the right-hand side of this figure a set of change gears is indicated. This is the gear by which the relation is fixed between the stroke of the cutting tool (which is decided by the width of the wheel face and the degree of spirality) and the stroke of the dividing slide which regulates the pitch. Since the direction of twist in the teeth of the two wheels of any spiral pair is of opposite hand it is necessary to reverse the movement of the dividing slide when the second wheel is being cut. This is carried out by means of the handle which can be seen projecting from the left-hand side of the bed in Fig. 112. This operates a bevel reverse gear. The dividing head, shown at *a* in Fig. 112, and which carries the blank, is driven by a pair of pawls. These have to be thrown over when the reverse is effected. These pawls have circumferential adjustment, so that when a blank is being cut which has previously been roughly grooved, the grooves may be brought to the correct position for tooth forming. This preliminary rough-grooving is desirable.

The arrangement of the tool holders is shown in Fig. 113, and to a larger scale in Fig. 116. Referring to this latter figure, the entire tool holder with its relieving mechanism is arranged to swivel on the tool slide *b*. The holders swivel on the axes X X which passes exactly through the important part of the cutting edges of the tools *c*, *c*, when they are held in their standard position. The swivel setting of the tools may consequently be slightly altered without affecting the correctness of their general setting, but it is not desirable seriously to disturb them after having adjusted them in gauge. The cutting tools are of simple form and are ground in a special fixture supplied with the machine. The fixture is adaptable to any standard cutter or tool grinder with a cup wheel. When a wheel is being formed, each cut is taken on every alternate cut round the blank. This distributes the effect of tool wear and heating uniformly round the blank and prevents any cumulative effect.

The feed of the blank is applied to a large feed sector *d* which is situated on the main table. It can be seen in Fig. 114. This sector carries the work saddle which is clamped on it at the pitch angle of the work being cut. The feed sector has to move through an angle equivalent to the addendum angle plus the dedendum angle of the teeth, plus an amount sufficient to clear the tools from the blank. These angles are read off on a scale and vernier *e*. Hand adjustment is made, a crank operating through mitre wheels and a tangent screw in the feed bracket, which can be seen at *f* in Fig. 115. The automatic feed is operated by an oscillating slotted lever *g* which is attached to a feed ratchet by a slotted lever. The setting of the work saddle to the cone angle of the gear being cut is by hand crank on the spindle *h*, which can be seen to the left-hand side of Fig. 112. This operates through bevel gears to a segmental rack fixed on the bed of the machine.

GAUGE MEASURING AND PITCH TESTING MACHINES.

A few interesting examples of gauge and gear-testing machines find place in the exhibition. Two of the most novel we now propose to deal with. The ordinary types of gear testers, while revealing the fact that gears may be faulty, do very little towards locating the actual cause of the trouble. Such trouble may be due to a number of causes, such as errors of tooth form, errors of pitch, or eccentricity of the pitch line with the bore of the gear. These errors may arise from a number of causes, such as the use of a gear-cutting machine of poor design or in bad repair, bad indexing in cutting, improper mounting or support on the mandrel, or, finally, to hardening and quenching. With the object of giving more information about gears when subjected to test, the Coventry Gauge and Tool Company have brought out a new machine, known as the Wickman gear pitch and concentricity measuring machine. This we illustrate in Figs. 119 to 123, Plate XLIV. It embodies some features common with the Wickman Universal measuring machine which we shall notice below, namely the method in which the stylus is supported, and the mechanical magnification of error secured.

The machine is very simple, and its application may be described comparatively briefly. The stylus arrangement will be clear from the view shown in Fig. 121, together with the sections in Fig. 119 and Fig. 120. The stylus is supported on a thin sheet of spring steel and a rocking-pin. This allows the stylus to move axially, and also to twist in a horizontal plane. The two indicating levers are connected by a compression member and two light tension members in the form of springs. The axial movement of the first lever influences the second lever only by the versine of the angle of the compression member, which is immaterial for practical purposes. The gear gives an indication for pitch or tooth spacing. The dial gauge shown gives the indication for concentricity accuracy. It is operated by the same stylus, the pin being set to bear up against a lug on the stylus head.

The instrument is used in the following manner: The gear to be tested is mounted on a mandrel on the conical arbor shown in Fig. 119, and clamped with a cone washer and nut. A stylus point is chosen corresponding to the pitch of the gear to be tested, and the top slide carrying the indicator gear is racked towards the gear until the stylus presses into it. The horizontal worm-wheel is then rotated until the swinging indicator lever reads zero. The micrometer reading disc in front of the machine has a loose rim, and this is next turned to zero and clamped. The rotating disc of the dial gauge is similarly set to zero. The worm wheel is next revolved the correct amount according to the micrometer reading-wheel and the stylus rocks over a tooth and slips down between the next two. The reading of the swinging lever is then taken, indicating any error of tooth spacing, while the dial gauge readings give + or − concentricity errors. These readings can be taken and curves drawn to show the results. A 30-tooth wheel can be tested and the curves plotted in less than ten minutes. The worm-wheel on which the accuracy of the machine depends is very accurately finished. The worm is mounted in a sliding box on slanting ways, by which means the worm can be moved towards the worm wheel centre to take up backlash. The end thrust of the worm is taken on a ball-end abutment with a spring to hold the shaft always hard up to it.

Due to the appreciation of accurate gauging which has been a direct result of the experience of the last few years there has arisen a demand for means of periodically checking gauges in use. Hitherto this has been considered delicate laboratory work for experts, and even so the methods employed do not eliminate the personal element sufficiently to secure agreement between different observers. In the case of microscopic measurements with 25 to 1 magnification the accuracy is still comparatively speaking poor, and is not sufficient for the highest class of reference gauge.

The Wickman universal gauge measuring machine shown at the stand of Messrs. Alfred Herbert, Limited, has been brought out by the Coventry Gauge and Tool Company, Limited, with the object of securing highly magnified measurements with an extremely light anvil pressure independent of the operator. The machine is illustrated in Fig. 124, subjoined, Figs. 125 to 130, on Plate XLV, and Figs. 131 to 133, on page 367. It will cover the following range of work: Length gauges up to 12 in.; major, core and effective diameters of screw plug gauges up to 6 in. in diameter, and pitch of same up to 4 in. diameter; pitch and major, core and effective diameters, of screw ring gauges up to 3 in. diameter; drunkenness of thread up to 4 in. diameter.

The machine will give comparator readings of

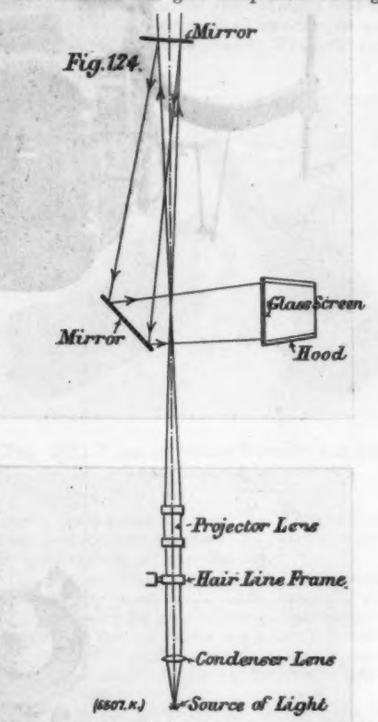


Fig. 124.

both diameter and pitch to an accuracy of 0·00001 in. and has proved itself possible of obtaining such measurements of length and diameter to an accuracy of 0·000005 in.

Our illustrations show various features of its construction. The general arrangement is shown in Figs. 131 and 132, page 367, and the general view Fig. 125, Plate XLV. The moving carriage and stylus gear is shown in the drawings Figs. 131 and 132, while other illustrations bring out points to which we shall refer as we proceed. The base is a stiff cabinet casting supporting on three adjustable supports a massive base heavily ribbed both ways on the underside, so as to reduce distortion to a minimum. The main carriage which has a movement of 4 in. is supported on this bed in a very novel manner which will be clear at once on reference to Figs. 127 and 128. The latter shows the top of the bed, and the former the underside of the carriage. The supports on the bed consist of four hardened, ground and lapped steel rollers, $\frac{1}{4}$ in. in diameter, and three sets each of three steel balls, $\frac{11}{16}$ in. in diameter. The rollers and balls are arranged so as to form between them a guiding V of 60 deg. The carriage is fitted with two long rollers corresponding to those at the back of the bed; these therefore guide the carriage, the remaining support being on a hardened and lapped flat steel strip seen in the upper part of the view of Fig. 127. The ends of the rollers are easily measured for parallelism and height and the arrangement is entirely free from sliding friction. The ease of movement is such that, though the carriage and

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

Fig. 131.

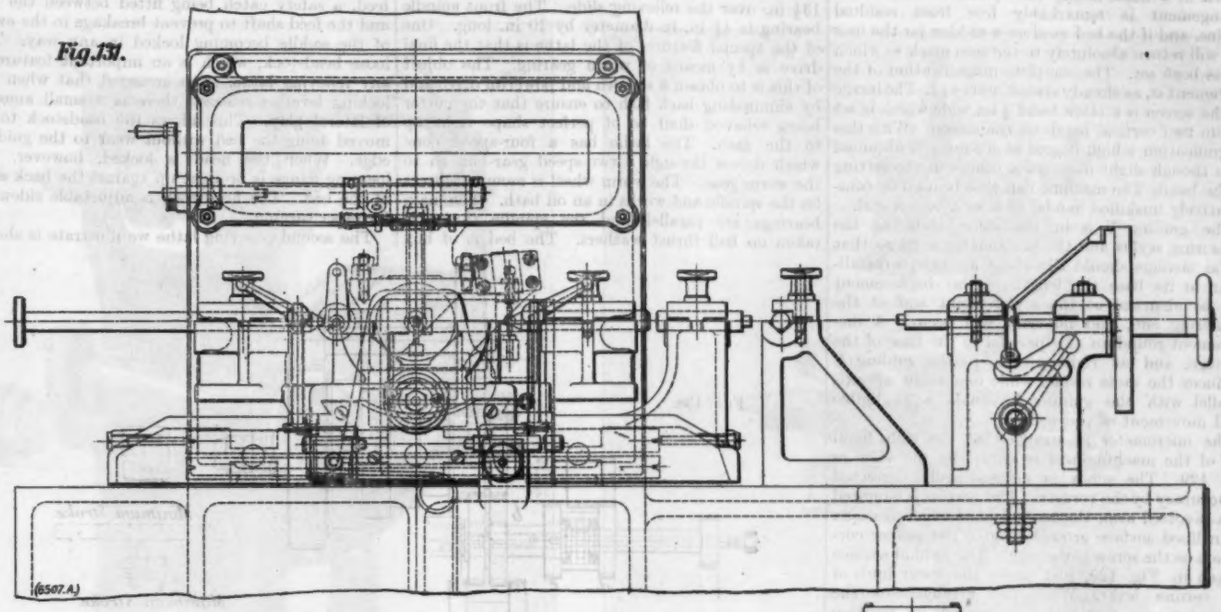


Fig. 132.

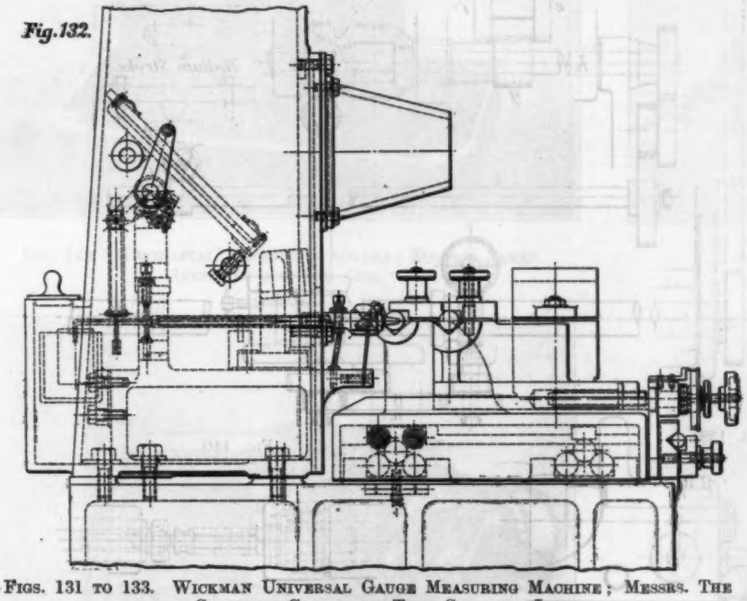
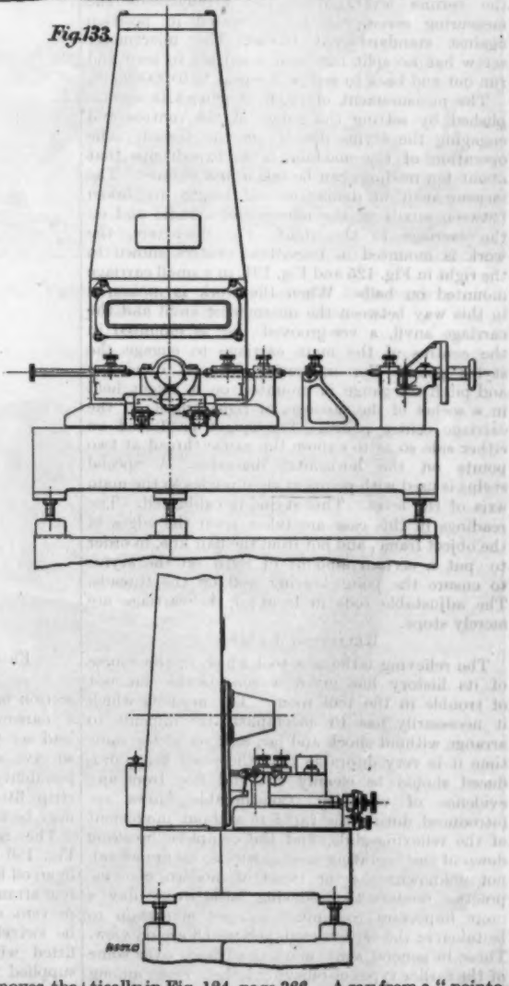


Fig. 133.



FIGS. 131 TO 133. WICKMAN UNIVERSAL GAUGE MEASURING MACHINE; MESSRS. THE COVENTRY GAUGE AND TOOL COMPANY, LTD.

gear weighs nearly 75 lb., the whole may be started from rest and kept moving by a 1½ oz. weight on the end of a cotton line running over a pulley. This renders the anvil pressure extremely light. The standard weight used to move the carriage is 1½ lb. It will be noticed from Fig. 128 that a very small portion of the bed is machined, namely the bosses taking the rollers, and small ways at the end. The ordinary period of seasoning required is thus much reduced. The bed is heat treated before final machining.

The magnification provided is 4000 to 1, which effectively eliminates the personal element. This is secured by a combination of mechanical and optical means. The mechanical part is shown in the drawings and in Fig. 126. High mechanical magnification is not satisfactory owing to residual strains. In the Wickman machine the mechanical magnification is only carried as far as 60 to 1, this being magnified again by optical means by approximately 70 to 1. Dealing with the mechanical portion first this consists of a stylus mounted on a thin sheet steel plate and supported by a pin (Fig. 132). This allows a certain amount of twist in a horizontal plane being given to the stylus, which is also free to take up a certain axial displacement. The twist imparted to the stylus forms the basis of the measurements taken on the machine. Towards the back end (Fig. 126) the stylus lever is coupled to another mounted on a pin, by means of a light compression bar, and two light wire springs. The compression member is only 3 in. long, and as the axial movement of the stylus only influences the second by the versine of the angle through which the compression member moves the amount is negligible for small movements. The levers are fitted with vanes dipping into oil pots as shown in Fig. 126, Plate XLV, which make them practically dead beat.

The optical magnification is shown diagrammatically in Fig. 124, page 366. A ray from a "pointolite" lamp is projected upwards into a mirror at the top of the hood, the necessary lens and condenser being interposed, with the object, a frame with a hair line, swinging between them. From the top mirror the ray is reflected on to one shown in

our drawing and from thence on to a ground glass screen in a hood facing the operator. The whole arrangement is remarkably free from residual strains, and if the bed receives a sudden jar the hair line will return absolutely to the zero mark to which it has been set. The complete magnification of the movement is, as already stated, 4000 to 1. The image on the screen is a black band ¼ in. wide which is set within two vertical bands on the screen. With this magnification a high degree of accuracy is obtained even though slight inaccuracy occurs in the setting of the band. The machine can thus be used by comparatively unskilled hands, such as a boy or girl.

The guiding V is in the same plane as the measuring stylus and the micrometer anvil so that if the carriage should tilt about an axis perpendicular to its base the length of the displacement will be identical at the stylus point and at the measuring end, and no error will occur. A displacement round an axis parallel to the base of the carriage, and at right angles to the guiding V produces the same result, while one about an axis parallel with the guiding V causes a negligible axial movement of the stylus.

The micrometer is arranged at the right-hand end of the machine and is shown by the view in Fig. 129. The screw is automatically corrected for accuracy by the vernier. The vernier is mounted on a pivotted arm, the lower end of which rests on an inclined surface ground to give the proper correction as the screw is run out. The ground surface is seen in Fig. 129, just under the lower limb of the vernier lever. With this arrangement the measuring screw can be calibrated in position against standard-sized blocks. The micrometer screw has no split nut, and when set to zero and run out and back to zero will repeat to 0·000005 in.

The measurement of pitch of gauges is accomplished by setting the gauge in the centres and engaging the stylus directly in the thread. The operation of the machine is so expeditious that about ten readings can be taken in a minute. The measurement of diameters and length are taken between anvils on the micrometer spindle and on the carriage to the right. For diameters, the work is mounted in transverse centres shown to the right in Fig. 125 and Fig. 131, in a small carriage mounted on balls. When the work is measured in this way between the micrometer anvil and the carriage anvil, a vee-grooved disc is mounted in the centres of the main carriage to engage the stylus' point. For measuring internal diameters and pitch the gauge is mounted on a spigot held in a socket of the carriage, at right angles to the carriage centre points. The spigot is slotted on either side so as to expose the gauge thread at two points on the horizontal diameter. A special stylus is used with points at right angles to the main axis of the lever. This stylus is calibrated. The readings in this case are taken from the edges of the object frame, and not from the hair line, in order to put a certain amount of twist on the stylus to ensure the point bearing well on the threads. The adjustable rods in front of the carriage are merely stops.

RELIEVING LATHES.

The relieving lathe is a tool which in the course of its history has given a considerable amount of trouble in the tool room. The motions which it necessarily has to accomplish are difficult to arrange without shock and jar, and yet at the same time it is very desirable that the work being produced should be cleanly cut and free from any evidence of vibration. Considerable forces are introduced during the rapid in-and-out movement of the relieving slide, and the complete breaking down of the operating mechanism is, we are afraid, not unknown. As the trend of modern machine practice renders the relieving lathe every day a more important tool much interest is certain to be taken in the various examples which are on view. These in general show marked advance over some of the earlier types of relieving lathe. From among the exhibits of this class we are this week illustrating two examples, both of which have points of originality.

The first machine illustrated in Figs. 134 to 136, on Plate XLVI, is built by Messrs. Ward, Haggas and Smith, of Eastwood Works, Keighley. The machine has a bed 6 ft. 4 in. long and 11½ in. height of centres. It will admit a job 22 in. long between the centres and 18½ in. diameter over the saddle or 13½ in. over the relieving slide. The front spindle bearing is 4¾ in. in diameter by 10 in. long. One of the special features of the lathe is that the final drive is by means of worm gearing. The object of this is to obtain a smooth and powerful drive and by eliminating back lash to ensure that the cutter being relieved shall be of perfect shape right up to the gash. The lathe has a four-speed cone which drives through a two-speed gear-box on to the worm gear. The worm wheel is mounted direct on the spindle and works in an oil bath. The main bearings are parallel, and the spindle thrust is taken on ball thrust washers. The bed is of box section brought right down to the ground, and has a narrow guide for the saddle. The rack and lead screw are fixed directly under this guide and so give a direct pull on the saddle without any possibility of cross-binding. The saddle has a strip fitted at the back to prevent lifting. It may be locked in any position when relieving.

The relieving slides which are illustrated in Fig. 136 obtain their motion from a cam running in an oil bath situated under the saddle. A cushioning arrangement is fitted to the bottom slide to prevent shock. The slides are universal and can be swivelled to any position, and all screws are fitted with micrometer dials. Three cams are supplied with the lathe giving 3 mm., 5 mm. and 7 mm. throw. The cam drive is taken from the headstock and at the opposite end of the lathe has mounted on it a change-wheel plate and gears to give the required number of relieving strokes to the slides. The spiral relieving change gears are connected up from the leading screw and the motion is transmitted through differential gears to the camshaft. The differential is enclosed and runs in oil. A feed-box gives three rates of positive feed, a safety catch being fitted between the box and the feed shaft to prevent breakage in the event of the saddle becoming locked in any way. The loose headstock, which is an important feature in any relieving lathe, is so arranged that when the locking lever is released there is a small amount of lateral play. This allows the headstock to be moved along the bed without wear to the guiding edge. When the head is locked, however, the locating flange is brought up against the back edge of the bed. The headstock is adjustable sideways for taper turning.

The second relieving lathe we illustrate is shown by Messrs. Smith and Coventry, Limited, of Gresley Ironworks, Salford, Manchester. Fig. 137, on Plate XLVI, gives a general view of the machine. It has 9½ in. centres and admits a job 33 in. long. The bed is 8 ft. 3 in. long, and the greatest diameter over saddle is 10¼ in. and over the profiling slide 7½ in. The greatest length of work which can be profiled is 11 in. The main spindle bearings are 4½ in. diameter by 5 in. long and 3½ in. diameter by 5½ in. long, and the spindle has a 2⅛ in. diameter hole through it. The spindle speeds range from 3½ r.p.m. to 130 r.p.m. The bed of the machine is of stiff construction, well cross-braced, and the centre line of the lathe is set back so that overhang of the saddle is minimised even when operating on jobs of large diameter. The guide for the saddle is in the form of a downward projecting lip which keeps clear of falling cuttings and scale. The headstock spindle, as already mentioned, is bored to take 2½-in. bars, making the lathe available for rough turning and cutting from the bar such articles as taps, reamers, &c. The thrust is

FIG. 138.

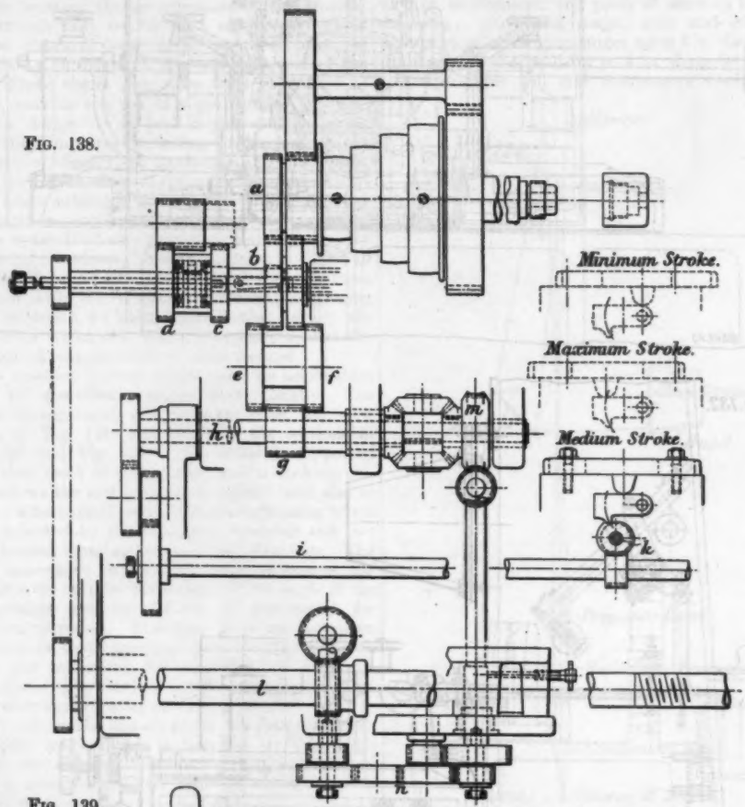


FIG. 139.

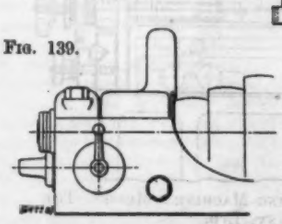
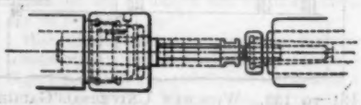


FIG. 140.



FIGS. 138 TO 140. DETAILS OF RELIEVING LATHE; MESSRS. SMITH AND, COVENTRY, LTD.

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

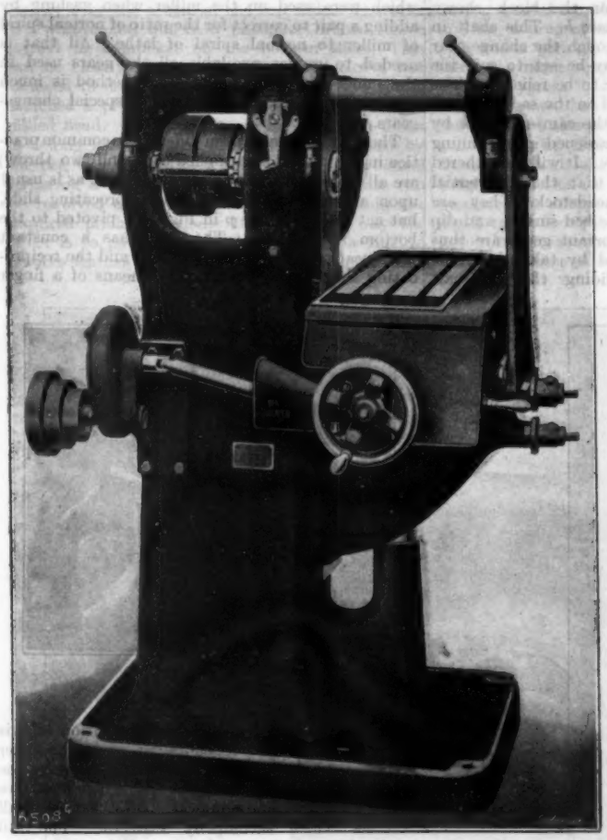


FIG. 148. HORIZONTAL REPETITION MILLER: MESSRS. JAMES ARCHDALE AND CO., LTD.

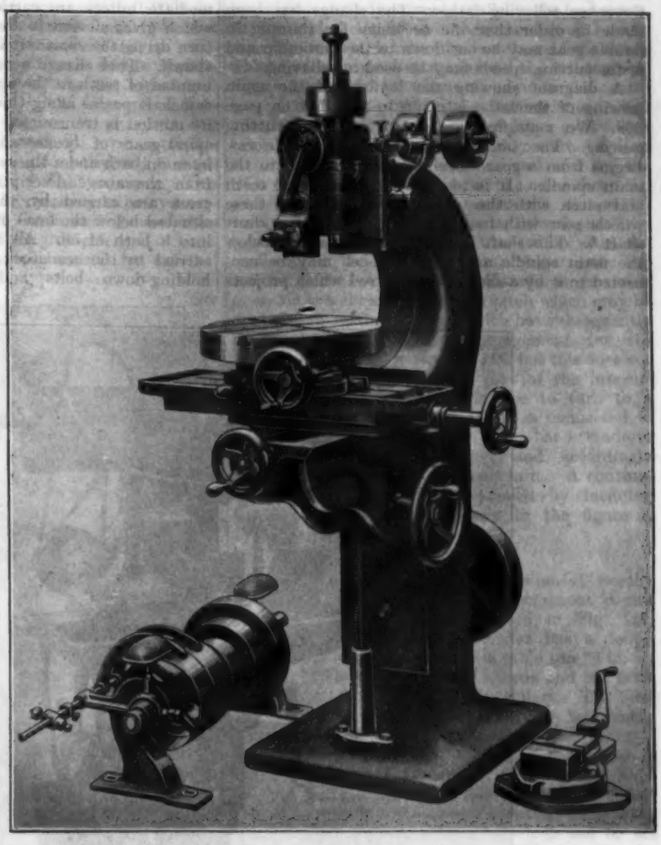


FIG. 150. VERTICAL MILLER WITH SLOTTING ATTACHMENT; MESSRS. GEORGE HATCH, LTD.

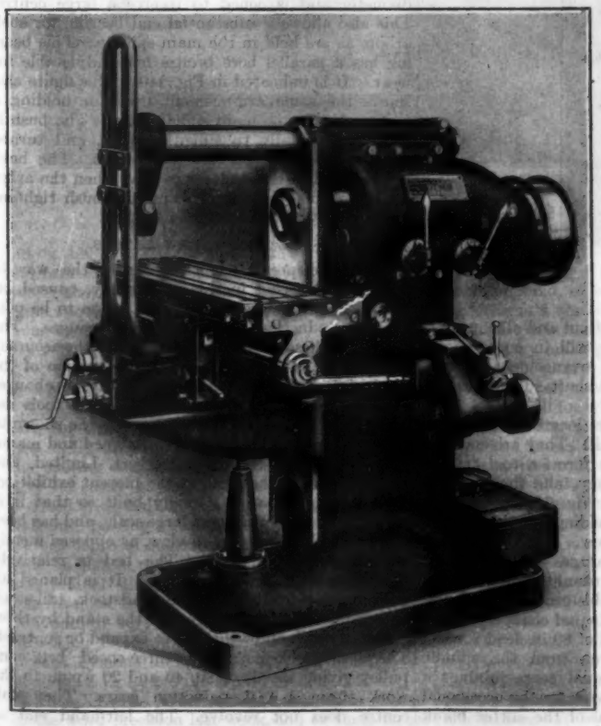


FIG. 149. AUTOMATIC MANUFACTURING MILLER; MESSRS. JAMES ARCHDALE AND CO., LTD.

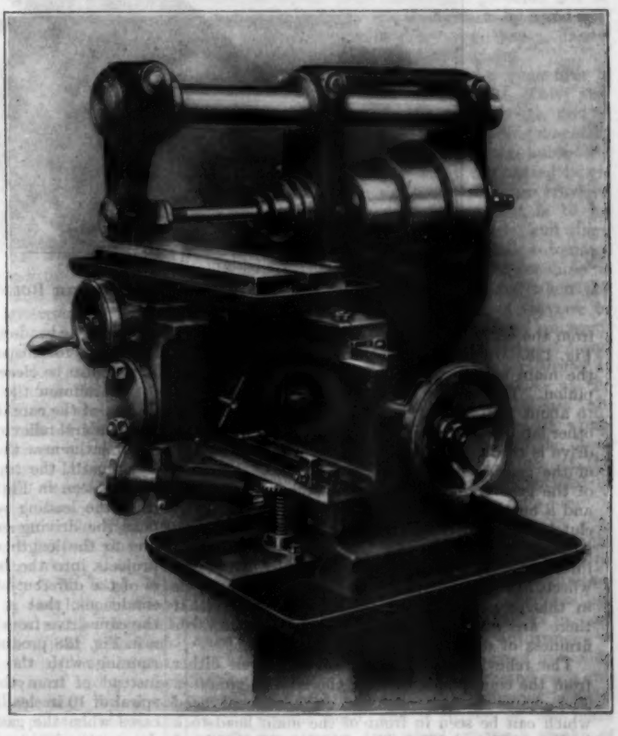


FIG. 151. "VILVALLE" HAND MILLER; MESSRS. W. A. WALBER AND CO.

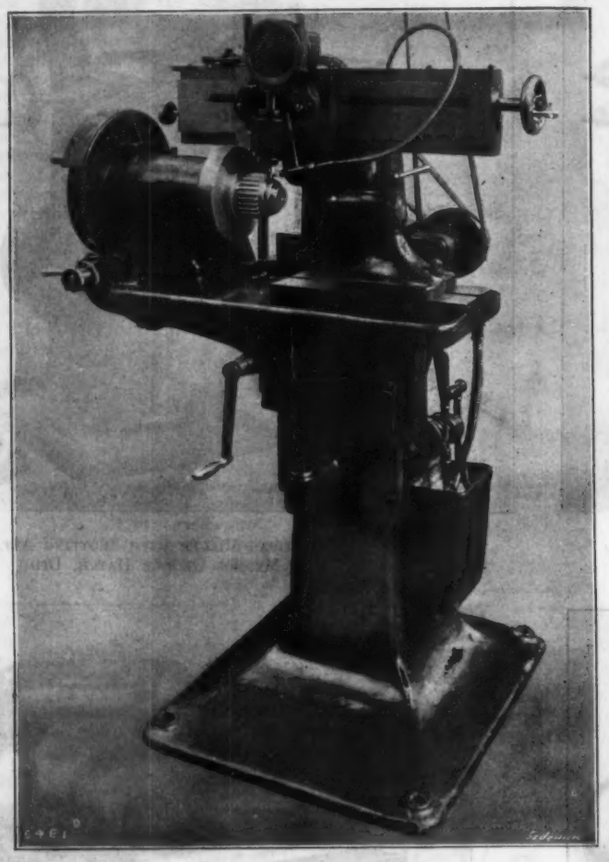
taken by a ball-bearing and the back gear ratio is 8 to 1. The cone drive is more powerful and the back gear ratio less than in earlier Smith and Coventry relieving lathes. The change has been made in order that the necessity for running in double gear may be cut down to the minimum and faster cutting speeds may be used in relieving.

A diagram showing the lay-out of the main gearing of the lathe is given in Fig. 138 on page 368. We may first deal with the screw-cutting gearing. The train driving the main lead-screw begins from a gear wheel *a* which is keyed to the main spindle. It is identical in number of teeth and pitch with the cone pinion. Each of these wheels gear with loose wheels running on a short shaft *b*. This shaft is situated immediately below the main spindle and either wheel may be connected to it by a sliding internal rod which projects from the end of the short shaft and is indicated in Fig. 138. In one position the rod gives a drive from the main spindle and in the other from the cone pinion. The first is used when cutting screws up to about ½ in. pitch, and the other when worms or other large pitch threads are to be cut. The second drive is through the back gear train and the value of the gearing is increased eight times. Reversal of the gear train is obtained by the two wheels *c* and *d* on the short shaft. They are controlled by clutches, one driving direct to the screw-cutting gear change spindle and the other through spur intermediaries which are shown above the two wheels in Fig. 138. It will be noted that all wheels in this gear run on permanent centres and that there are no tumblers. This all tends towards firmness of drive.

The relieving cam mechanism is driven either from the cone pinion or from the spindle pinion *a*. The change is controlled by an hexagonal head which can be seen in front of the main headstock in Figs. 137 and 139. The operation of this head places either gear wheel *e* or *f* as intermediary to drive the wide pinion *g*. This carries one of the mitre wheels of the differential, the opposite one being attached to the worm gear. The intermediate mitres are carried on the block shown which gives motion to the shaft *h*. This shaft in turn drives the camshaft *i* through the change-gear shown. This change gear may be set to suit the number of teeth in the cutter to be relieved. The camshaft passes along the bed to the saddle where its motion is transmitted to the cam spindle *k* by spiral gears of bronze and hardened steel running in an oil bath under the saddle. It will be gathered from the above description that the differential gears are carried by the headstock. They are situated below the level of the bed surface and dip into a bath of oil. All important gears are thus carried by the headstock, and by taking out the holding-down bolts and sliding the camshaft endwise, the head can be lifted out and all the gears laid open for inspection yet still in engagement. It will also be clear that the arrangement reduces to a minimum the length of shaft subject to the torsion of the cam-drive.

The spiral relieving gears are located at the front of the lathe near the headstock. They are enclosed in a guard, the top of which forms a tool tray as can be seen in Fig. 137. They take their motion from the leading screw, *l* in Fig. 138, at a point near the driving end, so avoiding torsional effect due to the length of the screw. The worm shaft projects into the bed and engages the worm gear *m* of the differential. When running under normal conditions, that is with double-gear engaged and the cam-drive from the cone, equal change gears at *n* in Fig. 138 produce a spiral of 80 in. lead; when running with the cam driven from the spindle instead of from the cone, equal gears produce a spiral of 10 in. lead. To provide for the occasional cases when the gashing spiral of the cutter blank does not coincide with any lead of the table, or obtainable with the gears supplied, the change gears of the train are carried on studs running in sockets in the jaws of a quadrant. One can accordingly easily adapt the actual change-gears which were used on the miller when gashing by adding a pair to correct for the ratio of normal spiral of miller to normal spiral of lathe. All that is needed to render available all the gears used in the miller is a few studs. This method is much less expensive than the making of special change-gears.

The relieving mechanism differs from common practice in that the cams supplied (one and two throw) are all of 10 mm. rise. They do not act as is usual upon a projecting stud in the reciprocating slide, but act upon a lever, *p* in Fig. 138, pivoted to the bottom swivel slide. The lever has a constant reciprocating movement of 10 mm. and the reciprocating slide bears against it by means of a finger on a bar fixed to the slide. The position of this bar is adjustable and depending on where the finger makes contact with the lever the slide receives the maximum on a reduced movement. The two extreme positions are indicated in the two small sketches which accompany Fig. 138. The tail stock of the lathe is of substantial construction and is arranged with cross-adjustment for taper turning. The two parts are clamped independently of the holding-down bolts. The spindle is of large diameter and is coned to receive a large centre. This also allows a substantial end bearing for such arbors as are held in the main spindle. This bearing has a parallel bore bronze bush adjustable for wear. It is indicated in Fig. 140. This figure also shows the same arrangement used for holding a taper arbor in the main spindle nose. The bush is tapered internally to suit the arbor, and turned parallel externally to suit the spindle. The bush is weakened in three places so that when the arbor is drawn home by the cap nut, the bush tightens both on the arbor and in the spindle.



FIGS. 152 AND 153. LEJEUNE TOOTH ROUNDER.

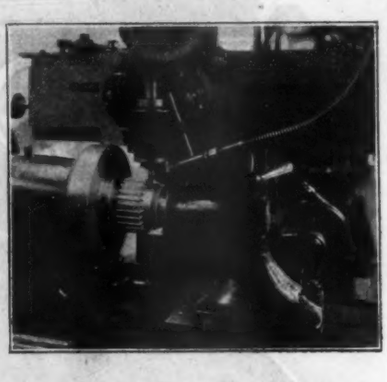


FIG. 153.

PRECISION SCREW LATHES.

The wide-spread adoption during the war of methods involving increased accuracy, caused, as is well known, a great deal of attention to be paid to the production of correct screw gauges. The cutting of these depend, of course, upon the accuracy of the methods adopted in the construction of the producing machine, with allowances for changes in hardening, &c. Among the precision tools developed for this work was the small lathe shown in Figs. 141 to 143, Plate XLVII, designed and manufactured by Messrs. Alfred Herbert, Limited, and being shown by that firm at the present exhibition. This machine is very strongly built so that it is suitable for shop work on a large scale, and has been evolved with this object in view, as opposed merely to a tool-room machine. The bed is relatively heavy for the size of machine. It is planed all over the top and carries the headstock, tail-stock and saddle. It is supported on the stand by three ball feet which allow the bed to expand or contract. The head-stock carries a three-speed belt cone pulley giving speeds of 80, 40 and 20 r.p.m. to the work through 4 : 1 reduction gears. The work centre does not revolve. The left-hand end of the cone pulley spindle drives the master screw through suitable gears.

The lead or master screw which is cut to a standard corrected on the pitch-correcting method adopted in this lathe, to Johansson blocks, is arranged exactly over the centre of the top slide. It works in a white-metal nut in a phosphor bronze sleeve carried in a bracket on the bottom slide. This can be clearly seen in Fig. 142. The sleeve has fastened to it an arm, to the outer end of which is attached a plunger in which is a steel peg with a milled head. The plunger can move up and down in a long bracket fixed to the slide, controlled by the peg which slides in a groove made of two steel strips on a plate set on the bed. This plate can be revolved through a few degrees, to obtain the required pitch variation. If canted one way the effect is to pull the arm down, and the nut to revolve against the screw, thus lengthening the pitch

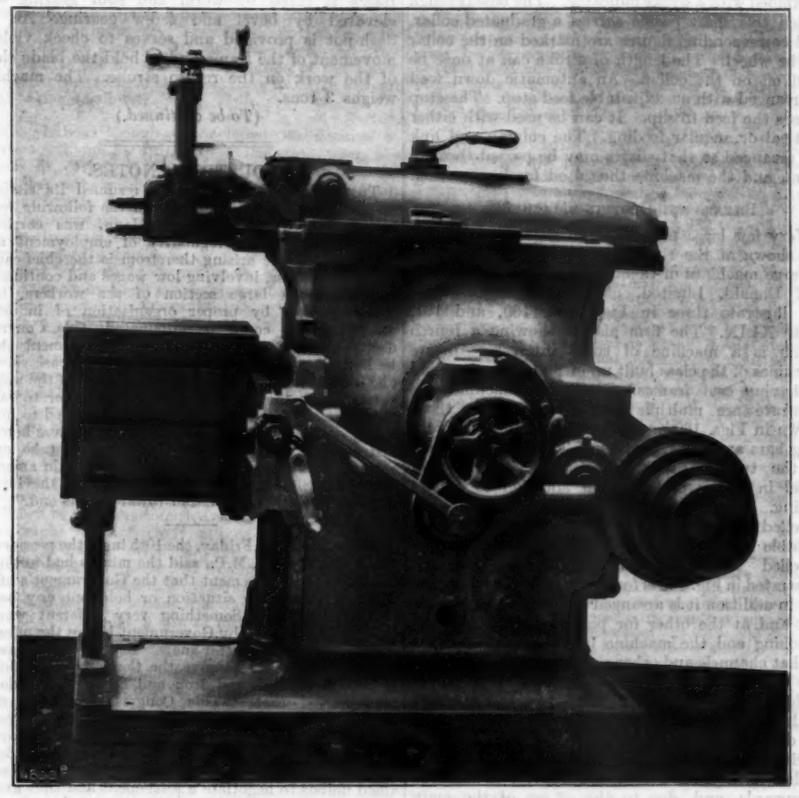


FIG. 158. 16-IN. SHAPER; MESSRS. GREENWOOD AND BATLEY, LTD.,

cut on the work. If the guides are set the other way the arm is lifted up and the pitch of the screw cut is shortened. The cam guides are set at the slope required by the characteristics of the steel from which gauges are being made. The arrangement is simple and the cam disc may be set to give changes of lead in the work of 0·0001 in per inch of screw by an indicator scale.

The tail-stock has fine adjustment across the bed, for the alignment of the centres. There are two slides on the saddle. The upper one carries the cutting tool, in an eccentric bush, so that it may be easily adjusted to the correct height. It is fitted with a quick withdrawal, and micrometer feed dial, reading to 0·0001 in., and stop, by which correct depth of cut can be obtained. The bottom slide is fitted with micrometer adjustment in a longitudinal direction. The work turned out on this machine is well up to N.P.L. standards.

A pair of very interesting high precision screw-correcting lathes which are exhibited by Messrs. Bryant Symons and Co., of 320, St. John-street, London, E.C. 1., are illustrated in Figs. 144 to 147 on Plate XLVII. We referred to the use, or misuse, of the word precision last week, and as these lathes really are precision tools the makers have endeavoured to emphasise the fact by prefacing the word "high." These lathes are all supplied with a certificate from the National Physical Laboratory and are guaranteed to produce work having a total length pitch error within 0·0004 in. in 8 in., a progressive error within 0·00015 in. per inch and a periodic error within 0·00015 in. We think the name screw-correcting is due to Messrs. Bryant Symons. It implies that the lathes will correct screws, but is not to be interpreted that they will not also make screws. What is intended and what is advised is that except for fine pitches the machines should be used for correcting threads roughed out on a tool of less accuracy. This increases the output of the precision lathe by keeping it to its own job and at the same time enables it to retain its accuracy for a greater length of time.

The building of separate machines for external and internal screw correcting has been determined upon as a matter of policy by the firm. A combined machine could, of course, be built, but throughout the designs a simple form of construction built up of simple parts has been aimed at, and this was best achieved by making separate machines for the two jobs. This policy has also enabled each machine to be designed specially to facilitate the carrying out of the job for which it is built, and such matters as tool setting and the operation of the various stops and levers have been made very simple and easily carried out. As the external lathe which is illustrated in Fig. 146, has been described in our columns in the past, we may confine our further remarks to the internal lathe shown in Figs. 144 and 145. The machine has an 8 in. face plate and is capable of dealing with gauge rings, nuts, &c., up to 4 in. inside diameter by 3 in. long. The spindle is parallel and runs in one long cast-iron journal with flat abutment faces and having end-wise adjustment. Three clamping jaws with packing pieces attached are supplied with the face plate for holding the work. Four forward and two fast reverse speeds are provided operated by clutch mechanism. A banjo plate is pivoted about the end of the lead-screw and carries the change-wheel studs, the wheels themselves being cast-iron discs with generated teeth. The upper surfaces of the bed are flat and two inner square faces form the guides for the saddle. The tool is mounted in a slide which has micrometer adjustment parallel to the lead screw, the tool slide being fitted in the cross slide of the saddle. The cross-slide runs on a vee rib and flat surface which extend some distance behind the bed to allow a spring-pressed back-centre to come to the centre line. This back-centre is a convenience when entering a testing plug in a ring gauge as it keeps the plug centred and maintains alignment. A stop is provided for this back centre and also for the slide on return. The lead-screw is carried down the centre of the bed and the nut is solid, the saddle being worked back by reversing the lathe. An automatic stop motion comes into action when the tool reaches the end of its cut. A corrector bar is fitted to the lead-screw to regulate for slight errors or to allow a slight variation in pitch which may be desirable in cutting a gauge which has subsequently to be heat-treated. The arrangement for the external lathe is shown in Fig. 147, but this does not differ in any essential from that of the internal lathe. The lead-screw nut is free to turn to a slight extent about its screw and is connected to a steel finger in the corrector. The bar is made to suit its particular lead-screw and accordingly corrects for any slight variations in it. A continuous variation in pitch is obtained by inclining the bar. The position shown in the figure is exaggerated.

MILLING MACHINES.

Among the milling machine equipment worthy of note is an automatic feed engagement device fitted to the machines illustrated in Fig. 148, page 369. This horizontal miller has a longitudinal traverse of 18 in., and a table top 26 in. by 10 in. It has twelve spindle speeds and six rates of feed by changing the cone pulleys. The feed engagement device allows the work to be quickly hand traversed towards the cutter, but when a predetermined point is reached the hand gear is thrown out and the automatic feed engaged, thus at once eliminating risk of damage to cutters, and loss of time in feeding up to the cutter. The work table has an adjustable tumbler which can be set for any point of the traverse. This tumbler depresses a plunger in a pivoted spring box. While the spring is still compressed, a small additional movement of the table allows this pivotted box to swing up and engage the feed clutch by a rod and lever. This machine is shown by Messrs. James Archdale and Co., Limited, Birmingham.

Another interesting miller by the same firm is illustrated in Fig. 149, page 369. This also has various unique automatic movements, and is termed a manufacturing automatic milling machine. Here again the chief interest is in the automatic movements. The machine has a self-acting longitudinal traverse of 28 in. and hand cross traverse of 6 in., while the vertical adjustment is 16 in. The change speed box gives six speeds, and there are nine changes of feed. The following automatic table movements are arranged. The machine is put into operation by moving a lever when the work is run up to cutters at a rate of traverse of 100 in. per minute. The feed is then engaged. After completion of the cut the feed is tripped and the cutter stopped. The table is then returned at the same high speed, and finally stopped at the point it started from. These movements are controlled by stops, one of which engages the working feed at the predetermined point, and the other the reverse and stop for the spindle. Once set, the operator merely has to attend to the chucking of the work, and restarting the machine by a lever.

We illustrate the small miller shown in Fig. 150, page 369, to show the slotting attachment with which it is equipped. The machine is by Messrs. George Hatch, Limited, Queenhithe, Upper Thames Street, E.C. 4. The table is 20 in. by 8 in. with longitudinal movement of 12 in. and cross traverse of 9 in. The vertical adjustment of the knee is 20 in. The spindle is carried in a slide having a vertical movement, by lever and rack and pinion, of 2 in. The slotting attachment is fixed to the spindle head, and is driven off the main spindle by a worm and wheel, giving a stroke of 2 in. to the tool slide. The slide can be canted 5

deg. either side of the vertical, and the gear instantaneously disengaged from the worm by means of a lever.

The hand miller illustrated in Fig. 151, page 369, is by Messrs. W. A. Walber and Co., 38, Victoria Street, S.W. 1. This machine is intended for precision work on jigs, gauges, &c. The table is 15 in. by 15 in. with a longitudinal traverse of 9 in. and transverse traverse of 3¼ in. The vertical movement is 5 in. The chief interest in this machine as illustrated is the swivelling table, for milling tapers, capable of being readily set to any inclination to a graduated disc. All three movements to the table are fitted with micrometer hand wheels reading to 0·001 in. The longitudinal slide is fitted with stops. A simple vertical spindle milling attachment is also arranged for this machine, which should prove a very useful small tool for the tool room.

Tooth Rounding Machine.

As a useful adjunct where much gear cutting is done the Lejeune tooth rounder is likely to find a place in a good many motor car and other works. This French machine is being introduced over here by Messrs. Alfred Herbert, Limited. It needs very little description as the two views we give of it in Figs. 152 and 153, page 370, are almost sufficiently clear of themselves. The machine is driven from a countershaft. The curves on the end of the teeth are formed by a cutter which has a horizontal reciprocating movement while the work is revolved. The reciprocating movement of the tool is controlled by a cam, driven from a three-step cone pulley. The length of the movement is adjustable for different pitch gears. The cutter slide has horizontal adjustment and can also swivel. The cutters are held by a draw-in collet in a spindle driven independently through helical gears. The work is driven by gears from the same camshaft which controls the cutter movement. The table can be adjusted vertically. The largest gear admitted is 16½ in., and the maximum pitch of gear cut is 2½ D.P. Between the centres the machine will take work 16 in. long.

Shaping Machines.

A large number of shaping machines are being exhibited, a good many of which present the now usual standard features. For some reason or other although the gear-box drive is adopted, with this tool, it is not nearly so common as in other directions, possibly on account of questions of cost. Most of the makers, however, have standard models of both types. In Fig. 154, Plate XLVIII, we illustrate a 14 in. to 16 in. machine by the Robson Machine Tool Company, Limited, of Keighley. This machine is being shown by the Atlas Engineering Company, of Leeds. It has one travelling head and two tables. It is belt driven by four-step cone pulley. The vertical feed to the tool-box is 6 in. The longitudinal traverse of the head is 4 ft. 6 in. The tables are 17 in. by 15 in. by 13 in. The ram carriage has automatic traverse in both directions and quick hand traverse. The tool-box can swivel, and has automatic variable feed. The saddle is wide and well supported on the slides. A circular mandrel with automatic feed is arranged in front of the bed. Its outer end is supported in a bracket on one of the tables.

Figs. 155, 156 and 157, Plate XLVIII, show respectively a general view and details of a 24 in. shaper by the Queen City Machine Tool Company, Cincinnati, Ohio, U.S.A., for whom Messrs. Alfred Herbert, Limited, act as agents. This is a very good looking machine with pleasing lines and designed with a view to handiness of control. The machine at the exhibition is driven by a single pulley and gear-box with gate change lever. The gears are all helical. There are eight speeds for every change of stroke, and 16 feeds. It is stated that work can be produced at full stroke on this machine to within 0·0005 in. on a side, and that the machines are tested for this before leaving the works. The whole machine is long and low and the saddle is wide. The table traverse is 27 in. with 15 in. vertical adjustment. The vertical traverse to the head is 8 in. The feed mechanism is completely enclosed in oil baths. The details of the feed gear are shown in Fig. 156 and 157. The control is by a small lever which is very easily moved and the feeds are capable of alteration while the machine is in motion, the indicator plate being graduated in fractions of an inch per stroke. Alterations of the feed are obtained by a cam allowing a pawl to pick up a varying number of teeth on a ratchet, according to the setting.

Messrs. Greenwood and Batley, Limited, Leeds, are showing the shaper illustrated in Fig. 158, page 371. This is a good standard machine with eight speeds and Whitworth quick return. The automatic cross feed to the table is 20 in. and the vertical feed to the tool-box 6 in. The eight speeds are obtained by means of a four-step cone pulley and a single lever which can engage two sets of gears. The length of stroke is varied by pinion gearing with a rack on the sliding block. The pinion is operated by a square ended shaft which is combined with a stroke indicator. The boss through which this shaft passes carries a graduated collar, and corresponding figures are marked on the collar of the wheel. The length of stroke can at once be read off on the collar. An automatic down feed is arranged with an adjustable feed stop. The stop causes the feed to slip. It can be used with either vertical or angular feeding. The column and link are arranged so that shafts may be passed through them, and the machine thus used for key seating.

Shears and Cropping Machines.

Very few large punching and shearing machines are shown at the Exhibition. The only examples of large machines of this class are by Messrs. Craig and Donald, Limited, of Johnstone. Of these we illustrate three in Figs. 159, 160, and 161, Plate XLIX. The firm also is showing a fourth which is a machine of some interest. All are machines of the class built up of plates, &c., instead of having cast frames. The three machines we illustrate are multiple purpose machines, those shown in Figs. 160 and 161 being mainly for cropping bars and rolled sections. The larger machine of the two is capable of cutting any kind of bevel in angles and tees, in addition to square ending. The cuts are very neat and clean and the bevelled ends fit together extremely closely. Adjustable stops can be used so that lengths can be bevelled without marking off. The machine illustrated in Fig. 159 is for cropping bars and angles, but in addition it is arranged at one end for punching, and at the other for plate splitting. At the punching end the machine is fitted with a block so that channels and other sections can be punched. The main frame plate of the machine is off-set slightly on a level with the lower shear blade. With this off-set the splitting of large plates presents no difficulty. The one portion of the plate is carried straight on the level on one side of the shear blades. The portion on the other side is deflected downwards, and, due to the off-set of the main frame, does not foul anything although the main frame of considerable thickness passes through the vertical V-shaped space thus formed in the plate being cut. The largest size of this class of machine made by Messrs. Craig and Donald will split plates 1¾ in. thick and cut 8 in. by 8 in. by ⅞ in. angles. The largest size of machine of the type shown in Fig. 161 will cut and bevel 8 in. by 8 in. by 1 in. angles. The fourth machine the firm is showing is a plate splitting machine also embodying the same feature of the off-set frame. The machines are either motor or belt driven and the slides are operated by eccentrics.

Sawing Machines.

A new design of cold saw intended mainly for dealing with girders and other rolled sections is exhibited by Messrs. Isaac Hill and Son, of St. Georges Works, Wood lane, Derby. The machine is illustrated in Fig. 162 on Plate XLIX. Although the saw is only 18 in. in diameter it is capable of cutting girders up to 10 in. by 6 in. This is made possible by the canting work table which enables the section being dealt with to be brought into the most favourable position for cutting. The table is worked by a screw and slide. The machine is driven through pulley on the countershaft by steel gearing. The main shaft runs in a ball-bearing at the driving end and a phosphor-bronze bush at the other end. The worm which drives the saw spindle slides with the saw carriage and is provided with a ball-thrust washer.

Another novel saw is shown by Messrs. Edward G. Herbert, Limited, of Atlas Works, Levenshulme, Manchester. It is shown in Fig. 163 on Plate XLIX. As will be seen it is a form of radial hack-saw. It is intended specially for cutting gates or runners for heavy steel castings, and will cut through a section of 24 sq. in. at a height of 6 ft., or less, from the floor. The machine is flush-sided and will cut close up to the face of a casting. In use it is bolted to a T-slotted floor plate on which the work can also be fixed. A tilting table is provided for dealing with smaller work. The saw frame can swing completely round the column and so can be moved well out of the way while the work is being handled by crane. The feed is by gravity with adjustable counterbalance and the frame is tilted by worm and spur gearing and elevated by bevel and screw gearing. An oil dash-pot is provided and serves to check violent movement of the frame and to hold the blade clear of the work on the return stroke. The machine weighs 3 tons.

(To be continued.)

INDUSTRIAL NOTES.

The Trades Union Congress resumed its sittings on Thursday, the 9th inst., when the following resolution, moved by Mr. Tom Mann, was carried: "Recognising that irregularity of employment and the loss of wages arising therefrom is the chief cause of social distress, involving low wages and continuous poverty for a large section of the workers, and believing that by proper organisation of industry unemployment could be eliminated, this Congress declares that responsibility for unemployment shall be borne by the industry, and that in no case should the level of income fall below 85 per cent. of the wages earned when in full employment. In order to raise the necessary funds power should be obtained to force a levy on the industry; and, further, Congress hereby instructs the Parliamentary Committee to take such action as may be deemed necessary to obtain amendments in existing legislation or to secure the introduction of further legislation towards that end."

At the sitting on Friday, the 10th inst., the president, Mr. J. H. Thomas, M.P., said the miners had nothing to add to their statement that the Government's offer did not change the situation or hold out any hope for a settlement. Something very different would have to be conceded by Government before the miners could consider the matter anew. Such was the answer he had been asked to give the Congress. Mr. John Hill (Boilermakers and Iron and Steel Shipbuilders) then moved that "This Congress condemns the attitude of the Engineering and National Employers' Federation in refusing to withdraw the lock-out notices to the members of the Electrical Trades Union, in view of the efforts made by the said union and allied unions to negotiate a settlement and thus avert a general suspension of public utility services already threatened in London and other centres." The resolution was carried after the president had remarked "that here was an occasion on which the workers themselves offered a court of inquiry, which was refused by the employers, the Government appearing to be taking no steps when the other side refused overtures of that kind." In this connection we call the attention of our readers to the letter which the Employers' Federation addressed to Dr. Macnamara, reproduced on page 342 *ante*, particularly to their statement to the effect "that the question at issue had been the subject of negotiations with the Electrical Trades Union and other unions interested at conferences every week for over a month . . ."

On Wednesday last an important development in connection with the miners' movement took place when the Miners' Executive asked for another interview with Sir Robert Horne, the President of the Board of Trade. The interview was at once arranged for noon, Thursday, and at the time of going to press its result has not been announced. It is concluded that in view of the Government's announcement that the coal industry will not be decontrolled while the present large discrepancy between the price of coal for export and home use continues, the miners will now be willing to drop the question of the 14*s.* 2*d.* and discuss the 2*s.* a day advance. Last week, of course, Mr. Smillie refused to place this question before the Industrial Court, but as he has since declared that they are not raising any question of nationalisation, and only want "a wage sufficient to enable them and their families to live in decency,"

there is no longer the least justification in refusing to take the matter to an impartial tribunal.

Another important turn has taken place in the electricians dispute. In this matter the National Joint Industrial Council for the Electrical Supply Industry, have communicated to the Minister of Labour a resolution passed on Wednesday announcing that the Electrical Trades Union was prepared to withdraw the question of principle arising out of the dispute at Penistone. As the Electrical Trades Union are represented on the National Industrial Council they are parties to this communication, and the way is now open for the withdrawal of the lock-out notices as well as the strike notices issued in London, and for negotiations to proceed in the ordinary way, subject to the Employers' Federation falling in with this new basis of negotiation. The Employers' Federation is not directly represented on the National Council. A conference of officials of London supply companies has addressed a protest to the Electrical Trades Union against these companies being drawn into a strike in which they had no concern or influence. They point out that the companies had no dispute with their workmen, and draw attention to the unconstitutional action of the Union in attempting to bind their members to strike without first taking a ballot.

The Labour Congress concluded its sittings at Portsmouth on Saturday, the 11th inst., when the president, Mr. J. H. Thomas, M.P., stated that the next few weeks would prove a testing time for Labour. Labour had to show that it was a united movement, and its representatives should not allow prejudice or passion to sway their judgments. It was not true that they were only concerned with their own sectional interests. He would despair of the future if the only end of their movement was wages and hours. Although they recognised the strength of their movement they were not out to prostitute or abuse it. They wanted a fair deal for their people and were going to have it. They should not in the next few weeks say or do anything that could render a settlement more difficult. Whilst Labour was determined to do justice to its own class it was equally determined to keep in mind the interests of the community as a whole.

The twenty-eighth annual report, 1920, of the National Free Labour Association has now been issued, and should be read in conjunction with the proceedings of the Portsmouth Labour Congress. A few paragraphs taken from it will be found of interest. It states, among other matters, that "the 25 per cent. of workers represented by organised labour have absolutely no interest in, or regard for, the other 75 per cent. In fact, the moment a trade union gets strong enough it begins the policy of restricting membership, restricting apprentices, restricting output, and in every way limiting and controlling the particular industry for the advantage of its own members and the disadvantage of others, whether they be employers, or boys deciding to learn a trade . . . Six years ago bricklayers laid 1,360 bricks a day, for 10½*d.* per hour, while now they are paid 1*l.* a day and they only lay 300 . . . Trade unionists should not lose sight of the fact that at least two-thirds of the wage-earners of the country are either non-unionists, or trade unionists by compulsion . . . No one desires to deprive organised labour of getting its proper share of the profits of industry, and no one can take exception to the principle that every man shall get all he can earn; but that organised labour shall be permitted to conspire in every possible way to fleece the public is against the best interests of the community, and it is the duty of Government to take immediate steps to eliminate the evils which are now causing so much unrest and discontent . . . The National Free Labour Association represents a million working men who are non-unionists by conviction. They believe in individual effort and individual promotion. They consider that if wages were fixed by merit instead of at a dead level they would be better off. They do not agree with the political views or the methods of the trade unions. They do not want to remain workmen all their lives. They hope to be some day promoted to foremen or even higher. They are individualists and claim the Englishmen's right to join any body they please . . . Every rise in wages which is not accompanied by an increase in output is a disaster. No wage is too high if it is an earned wage . . ." The offices of the association are at 5, Farringdon-avenue, E.C. 4.

Speaking in Glasgow last Saturday, Mr. G. N. Barnes, M.P., said that taking England and Scotland together, this year there were actually 300,000 less acres of land under cultivation than last year. Therefore, we should have to import more food, and it was absolutely necessary that we should be in a position to pay for it. Even if there were no coal strike, we should have 50,000,000 tons of coal less to pay for our food than we had in the year before the war. At present we were importing into Glasgow steel at 23*l.* 8*s.* per ton from America, whereas the lowest tender from the home producer was 28*l.* per ton. Thus we were importing 10,000 tons of American steel at a cost of about 45,000*l.* less than we could make it ourselves. That was a very serious fact, and we must either produce more food for ourselves or produce those things by which we paid for our food, better and cheaper than other people could do.

GERMAN COMBINATION IN ENAMELLED WARE GOODS.—According to the *Frankfürter Zeitung* the former association of German enamelled ware factories, which has existed without definite Articles of Association for a number of years, was dissolved at a recent meeting. In its place a new confederation of German Enamelled-ware works has been founded, its members embracing over 60 factories, representing about 80 per cent. of Germany's production. The Confederation will control and give information in respect to foreign markets. The first meeting of the new Confederation agreed to prices being lowered by 20 per cent., so that export prices must be correspondingly lowered. The increases on goods of particular quality have also been defined. New prices come into force on September 30, but only in respect of those contracts in which deliveries will be made before December 31.

OXYGEN-AIR FOR METALLURGICAL OPERATIONS.—In considering the possibility of using air enriched in oxygen for working blast furnaces, F. G. Cottrell, in a paper read before the American Iron and Steel Institute last May, stated that the oxygen plants of the United States could produce about 130 tons of oxygen per day, and 95 per cent. of it was used for cutting and welding. One-quarter of this oxygen was made in several hundred private electrolytic plants; the bulk came from the plants of the Linde Air Products Company and the Air Reduction Company (Claude); in a few plants the Hildebrand process was still used. The biggest oxygen plant of the world had been built during the war by the Government at Muscle Shoals, Alabama, for nitrogen fixation; that plant might yield one-fifth of the oxygen a blast furnace required daily for producing 500 tons of iron. Separation of atmospheric oxygen and nitrogen by centrifugal processes or by solution of air in water and reliberation of the air by reduced pressure looked hopeless. Considerable improvements could, however, be effected in the actual separation plants if they were made integral parts of the original design of metallurgical works. The temperatures of most iron blast-furnace operations being defined by the melting-points of the charges, the enrichment of the blast would not be of much advantage; it could only hasten the reactions, unless we modified the composition of the charges or the construction of the furnaces. The blast-furnace gas would, however, be more valuable, and in the open hearth and in the gas producer the volumes of gas circulating would very much be reduced by using an enriched gas, with manifest advantages. In the converter again the use of oxygen would do away with the necessity of applying silicon also for its fuel value and might otherwise lead to unexpected results. In the short blast furnaces for copper and other sulphides and in furnaces in which metal or their compounds (such as zinc, cadmium, mercury) are to be volatilised the partial replacement of air by oxygen also promised advantages.

ELECTRICITY IN SWITZERLAND.—The Commercial Secretary to His Majesty's Legation at Berne draws the attention of the Department of Overseas Trade to the increasing demand on the part of the public in Switzerland for cheaper electric current. At the present day when coal, petrol and other fuels are scarce and expensive, the public is turning more and more to electricity for heating purposes, and efforts are being made to increase the number of water power stations for the production of cheaper electric current. Unfortunately the cost of building the water power stations has increased enormously of late, and it has been stated that the costs of erection are treble, and in some cases fivefold, what they were before the war. Electric power stations in the country, with very few exceptions, have been obliged to raise the price they charge for current. It has been suggested that there are at present only two ways of supplying electric current at cheaper rates: One consists in erecting larger power stations and constructing more extensive artificial lakes in the high-lying mountain valleys. A second suggestion is to encourage the use of electric current during the night by reducing the charge during these hours. In towns current is being increasingly used for household purposes: ironing, cooking and numerous other household work. Baking by electricity is rapidly increasing. A new industry is also growing up in Switzerland for the construction of electric stoves for the heating of private houses. The current used for these stoves is generated at night, during which time the stoves are heated up. In the morning the current is cut off and the stoves remain warm during the whole of the day. In all modern houses and hotels, a large quantity of water is heated by electricity, the current for which is produced between midnight and 6 a.m., and provided at a cheaper rate. It is asserted that if the price of current used at night can be sufficiently reduced, electric heating in Swiss houses will become the rule. The Commercial Secretary is informed that the "Bulletin de l'Association suisse des Electriciens" has been making a special study of the possibility of utilising current more extensively, if its price can be sufficiently reduced.

THE TRADES UNION CONGRESS AND THE INDUSTRIAL SITUATION.

IN the course of an important letter published in *The Times*, yesterday, Lord Weir, referring to the proceedings of the Trades Union Congress at Portsmouth writes:—

"A Trade Union Congress which would have dealt with the known and obvious factors, which during the last two years have been largely instrumental in causing inefficiency of production, and have definitely increased the cost of living, would have done much to convince the community of the statesmanship of Labour. For example, a strong recommendation from that Congress to the trade unions of which it is composed, urging that they should sit down with the employers' organisations and deal at once with the problem of freedom of employment and of remuneration by results in a genuine and sincere spirit of co-operation, would have gone far to show that Labour really desires to bring about stability and contentment in the industrial world.

"Let me recite a few other practical questions which this Labour Parliament might have dealt with to assist production promptly and effectively, and at the same time to strike the much-needed keynote of helpfulness in to-day's difficult industrial situation. The lock-out brought about by the policy of the Electrical Trade Union threatens the productivity of the engineering and certain other allied industries. The Congress might easily have told the Electrical Trades Union that to-day Labour as a whole continues to recognise that it is a legitimate and justifiable function of the directional authority in industry to appoint foremen without discrimination as to whether or not they are members of a trade union, and that the Electrical Trades Union are causing grievous harm to trade unionism by adhering to their present attitude, and that to-day our country's industries and the workers' own future welfare are being impaired by such illegitimate claims.

"Again, there exists to-day on the Clyde a dispute between ships' platers and their helpers, a dispute which is seriously affecting the building of ships, and a dispute in which the employers have no part. Why does the Parliament of Labour not take up an issue of this character and publicly advise the unions to stop quarrelling among themselves, instruct their men to go back to work, and allow their differences to be settled by an impartial committee of other trade unions?

"Or, again, they might have agreed to appoint a committee to investigate the influence of the policy of the Ironmoulders' Society on the prevention of employment and on the restriction of output in the ironfoundry industry. Such an investigation would establish that millions of pounds' worth of British engineering products were not being made and exported from Great Britain to-day because there do not exist enough members of the Ironfounders' Society to enable the necessary castings to be made, and that the Ironmoulders' Society will not permit ex-soldiers, disabled men, unskilled men, or women to be trained and employed to assist in bringing about the output required, thereby increasing our exports, helping to pay for our imports, and bringing down the cost of living. British engineering firms in many cases are to-day only able to retain in employment a portion of their engineering and other workmen by importing castings from France and Belgium. Other employers have had to pay off considerable numbers of engineers and other workmen on account of their inability to secure the necessary castings for these trades to work upon. I commend to the particular attention of every member of the community, and especially to the individual members of the Ironmoulders' Union, the extraordinary situation they have created. It is, indeed, a strange quality of mind which is directing a British trade union to accept with equanimity the situation of British engineering firms paying wages to an unskilled Belgian working on payment by results in Belgium to produce castings for Britain, and which at the same time prevents by every means in its power these same firms from employing an out-of-work, unskilled Britisher, even an ex-soldier, to carry out that same work. Evidently this kind of phenomenon, which is at the root of to-day's industrial inefficiency and of high prices, is of indifference to the Trades Union Congress, who conceive it to be of more importance to Labour and the community that their enthusiastic efforts should rather be directed to vehemently protesting against the absence of Bolshevist delegates from Portsmouth, or to the condition of health of a prisoner in Brixton gaol."

THE BRITISH ASSOCIATION HANDBOOK TO CARDIFF. ERRATUM.—In our issue of August 27, on page 285 *ante*, we had, in a footnote, meant to describe the "Handbook to Cardiff and Neighbourhood" as a 16mo publication of 314 pages. By an unfortunate misprint it was styled a 16*s.* publication. We regret the mistake; the interesting handbook was presented free of charge to members and was not for sale. As the description of the size might also be questioned, we add that the volume forms a pocket book of 6½ in. by 4¼ in.

PERSONAL.—Owing to continual expansion, Messrs. The Cambridge and Paul Instrument Company, Limited, have found it necessary to centralise their business organisation in London, and they have established head offices and show rooms at 45, Grosvenor-place, S.W. 1. (Telephone: Victoria 7640.)—We are informed that the Institute of Cost and Works Accountants is removing to larger premises on September 9, and on and after that date its address will be 38, Grosvenor Gardens, Victoria, S.W. 1 (Telephone: Victoria 6776). A library is now in course of formation for the use of members and a reading room is also being provided.

LOCOMOTIVE HEADLIGHT TURBINE GENERATOR.

On the American Continent and elsewhere where tracks are not so well fenced and protected as they are with us, it is the custom to employ powerful headlights on locomotives. Present practice is to adopt a small turbine electric set, and one such we now illustrate in the accompanying figure. The drawing is fairly clear and requires only a brief explanation. This unit is designed and manufactured by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., U.S.A. Its capacity is 500 watt at 33 volts, direct current. The steam inlet will be noticed at the right hand end of the machine. From there a passage takes the steam to the nozzle block and reversing chamber. The turbine rotor shaft is fitted with labyrinth packing which prevents leakage to the atmosphere. On the right-hand side of the rotor is fitted a governor which, it is stated, regulates to within 3 per cent., the needle valve being clearly seen at the steam inlet.

The generator rotor is fitted with ball bearings. It runs at 4,000 r.p.m. It is compound wound. It will be noticed the set is very simply arranged. The whole of the steam end can be removed for the inspection of the turbine rotor, governor and valve. Also by removing bolts on the turbine end of the generator frame the armature may be removed and the field removed without breaking any wiring. The unit is weather-proof and dust-proof, and is designed especially for service under exposed conditions.

HYDRAULIC-FILL DAMS.*

By ALLEN HAZEN, M.Am.Soc.C.E.

THE hydraulic-fill method of dam construction grew out of hydraulic mining. It was natural that a process conspicuously successful in mining on an enormous scale, and that moved material at very low unit costs, should find other applications.

The late James D. Schuyler and J. M. Howells, Members, Am.Soc.C.E., were pioneers in the application of hydraulic methods to dam construction. Mr. Schuyler presented a paper† to the Society in 1906 setting forth in a most admirable way the peculiarities of the method and its application to actual dams.

The method is certain to have an important place in future dam construction. It has two fundamental advantages: First, in sorting out the fine particles and placing them in the centre of the dam, thus insuring complete water-tightness; and second, in the use of power in place of muscle to the greatest extent, so that the labour cost and the animal cost of construction are reduced to a minimum.

It is sometimes possible to place material by the hydraulic process at much smaller cost than by any other method.

On the other hand, several hydraulic dams have not proved to be stable. Failures, usually during construction, have caused great losses, and their occurrence has been discouraging.

There may have been more than one cause of failure, but one cause has certainly predominated. In the interior of the dams there have been masses of clay and other fine-grained material, that have not consolidated to the point of stability. Instead of forming an integral part of a solid dam, these have remained in almost liquid form, dividing the dams and tending to disrupt them. In this respect, hydraulic-fill dams are on a different basis from other earth dams.

If the hydraulic method of dam construction is to be successfully used, this element of weakness must be eliminated.

There seem to be two promising ways of eliminating it. The first and most natural one is to increase the size of the dam until the solid parts forming the toes are amply strong to resist the full fluid pressure of the unstable core. The second consists in selecting material and handling it in a way to secure drainage and consolidation of the core, so that the whole dam will act as one solid mass.

If core material can be fully drained and consolidated, there is no reason why a dam built by the hydraulic method on a section that is suitable for an earth dam built dry should not be safe. If drainage and consolidation of the core is not secured, however, safety can only be reached by making each toe large enough to stand the full pressure of the liquid core, and in that case, in order to be safe, a dam built by the hydraulic method must have flatter slopes and a larger section than is otherwise needed for an earth dam.

It is interesting to note that Clemens Herschel, past-president, Am.Soc.C.E., in discussing Mr. Schuyler's paper in 1906, made the point that a larger section would be required for stability; Mr. Schuyler took exception to this, and stated that in his experience there was no reason for building a dam of greater dimensions because the material was placed in it by the hydraulic method.

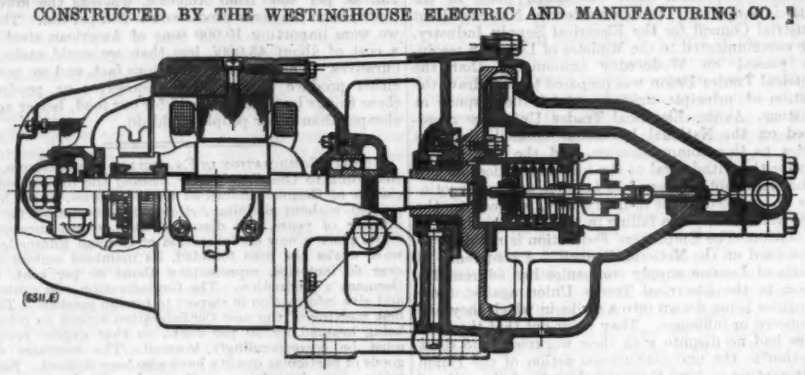
The advantages and economies of the hydraulic method are such that it will often be good business to use it, even though the required volume of the dam should be greater. If work can be built at half the cost per cubic yard, twice as many cubic yards can be placed for the same money.

* Paper read before the American Society of Civil Engineers.

† Transactions, Am.Soc.C.E., Vol. lviii, page 196.

LOCOMOTIVE HEADLIGHT TURBINE GENERATOR.

CONSTRUCTED BY THE WESTINGHOUSE ELECTRIC AND MANUFACTURING CO.



The number of failures with hydraulic-fill dams growing out of this fundamental condition of fluid cores and inadequate toes has been such as to make it clear that this condition of instability has not been recognised in the designs. Mr. Schuyler's excellent paper contains no discussion of this point. Looking at it from the standpoint of thirteen years afterward, it is easy to see how this condition could have been overlooked and to see, also, how some of the early failures were attributed to other causes.

Now, however, enough experience has been gained so that a better analysis may be made. To insure success with future hydraulic dams, this analysis must be thorough. It is the writer's thought that it will be possible to make it in a way to secure as high a degree of safety in hydraulic-fill dams as is required, and is customary, in other engineering structures. It may be that we do not yet have all the necessary data; but, if not, the best way to find what is lacking is by using what we have.

Fig.1. CROSS-SECTION OF DAM NO. 2 AT NECAXA, MEXICO, SHOWING DIMENSIONS, CUT-OFF TRENCHES AND THEORETICAL DISTRIBUTION OF MATERIALS.

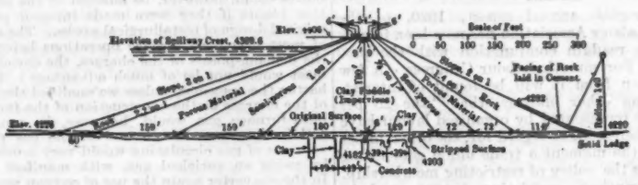


Fig.2. TYPICAL SECTION OF HYDRAULIC FILL DAM DURING CONSTRUCTION.

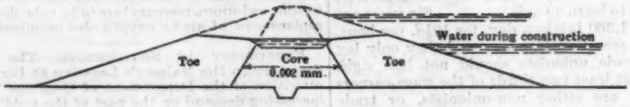
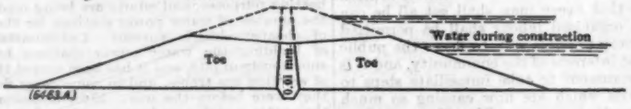


Fig.3. ILLUSTRATING PROPOSED SECTION WITH NARROW COARSE-GRAINED CORE.



Character of Core Material.—The first point to be considered is that, in many or perhaps most hydraulic-fill dams, the core material is so fine in grain size that it is incapable of drainage. By that is meant that it is incapable of drainage within a reasonable length of time. The lower parts of the core do not become stable before the upper parts are placed upon them.

In general, all the material placed in hydraulic-fill dams may be divided into two classes, namely, toe material and core material. Mr. Schuyler presented a picture of materials divided into several classes, the coarsest being found at the outside and the finest in the middle (Fig. 1*). Practical experience does not show that the material is graded in quite that way. There is some grading in the toes and the average size of particles near point of delivery of material near the outer slopes is greater than away from those points and near the core; but, practically speaking, this gradation is not very important. Ordinarily, all the toe material is of coarse particles when first placed. Afterward, passage of silt-laden water from the operation of hydraulicing partly fills the voids with fine material, but the process stops itself before they are all filled. The toes readily drain and all the stability naturally inherent in the stock is obtained.

The core may be defined as that part of the dam deposited from water in the central pool. In the writer's experience, core material is homogeneous. At any level there is no appreciable difference in grain size between the middle of the core and its farthest extremities.

The principles determining the size of particles deposited in the core, or not deposited, are the same as the ones that apply in a sedimentation basin of a water-works plant. The larger the area of the pool in proportion to the quantity of water that goes through it, the more complete will be the subsidence, and the smaller will be the limit of size of particles retained.*

Most hydraulic-fill dams have been built with good-sized pools in the centre during construction (Fig. 2), in which sedimentation has been fairly complete. The writer has examined samples of the core materials from a number of dams. The samples are rather surprisingly alike in grain size. They ordinarily contain particles in large quantities down to a limit between 0·001 mm. and 0·002 mm. (or sometimes 0·003 mm.) in diameter. Generally speaking, all smaller particles have been carried away by the escaping water and have not remained in the core.

It should be said that the determination of the exact size of these small particles is by no means as precise as the determination of the size of grains of filter sand. The results are reached by the microscope with a micrometer and are to be considered as roughly approximate only. It has been the intention to use a basis as nearly as possible comparable to that adopted for the larger particles in sand analysis, which is to use as the diameter of any particle the diameter of a sphere of equal volume. Following this rule the width, rather than the length, of small particles is measured.

Core material then, as a matter of observation, consists of particles from this size up to the size of the smallest particles retained in the toes. In a general way, this size may be taken as 0·03 mm., or 10 to 15

* Fig. 1 is reproduced from Transactions, Am.Soc.C.E., Vol. lviii, page 243.

* "On Sedimentation," by Allen Hazen, M.Am.Soc. C.E., Transactions, Am.Soc.C.E., Vol. liii (1904), page 45.

times as great as the limit of size of particles that are retained in the core.

Speaking of core materials in the terms that are used in describing sand, it may be said that the effective size of core material is ordinarily about 0·002 mm. This size is so small that one who is not accustomed to microscopic work has little conception of it. For comparison, it may be stated that ordinary filter sand has an effective size of from 0·3 mm. to 0·4 mm., while dune sand, being the finest material usually spoken of as sand, has effective sizes ranging from 0·15 mm. to 0·20 mm.

Without attempting precision, and using round figures, the core material is one-hundredth of the size of dune sand. This means (assuming that the laws of flow and the laws of capillarity applying to the finest sands apply also to these still finer materials) that, other things being equal, the drainage of core material will take ten thousand times as long as corresponding drainage of fine sand. Fine dune sand would drain as much in an hour as core material in a year. It means, further, that the height to which water can be held by capillarity is ten thousand times as great as the height at which it is held by fine sand. If fine sand will hold water by capillarity to a height of an inch, as it will, then core material like that shown by the samples will hold water by capillarity to much more than the full height of any dam.

The reason why this core material does not drain is therefore clear. It seals itself up and becomes practically water-tight.

With the dimensions existing in dams that have been built, assuming that the laws of flow known to apply to the finest sands apply also to the still finer materials, it will take years for the excess of moisture to drain out, as it must do before the solidification of the material is possible.

As a practical proposition, drainage is not possible with such fine materials. By that is meant such prompt and complete drainage as will result in solidification during the construction of the dam.

Construction records and samples show approximately what happens. Core material of the fineness already described goes down first in the form of soft mud in which the voids filled with water are at least 70 per cent. of the total volume. Such mud is very soft.

The percentage of voids furnishes, on the whole, the best index of consolidation and stability. In itself, it is not an adequate basis of comparison, because different kinds of core material may have different degrees of stiffness with the same percentage of voids; but, notwithstanding this difference, the percentage of voids is the best index of consolidation so far available.

The material when it goes down contains 70 per cent. of voids. Under these conditions, the minute solid particles are held apart by the water contained between them, and the passages through which water can pass are much larger than they would be with a more compact arrangement of the same material. Water drains from this material gradually, and the material consolidates.

The drainage may be horizontal, in which case the surplus water finds its way through the core material to the toes and escapes. There is, however, a shorter way out, and it appears probable that most of the drainage takes place vertically. That is to say, the solid particles settle down and consolidate while the water moves upward between them to the top. This consolidation takes place gradually at rates depending on the dimensions of the dam and also on variations in the effective size of the core material; for while the writer considers all this material broadly as having an effective size of 0·002 mm., there are no doubt considerable variations in size and permeability.

Experience shows that consolidation goes on so that after a period of from a few months to two or three years in the ordinary course of dam construction, it will have been consolidated to a point where the voids are about 50 per cent. As the consolidation increases, the sizes of the passages between the grains become smaller, and the flow becomes less rapid and the process of consolidation goes forward more and more slowly.

Material with 50 per cent. of voids when taken out of a boring is described as material having the consistency of stiff putty. It is capable of standing up in a boring driven beyond the casing for several feet, and it offers great resistance to penetration.

One of the best field methods of testing the consolidation of core material has been to find the depth to which a 1¼-in. pipe could be forced into it by two men. This method of testing has been used in several dams. It has been possible to co-ordinate the penetration so found with records of the percentage of voids. In a general way, penetration by 1¼-in. pipe pushed down by two strong men extends to the point where the voids are about 50 per cent. In other words, the 50 per cent. material is so stiff that it can no longer be penetrated to any considerable depth by this method.

Tests of material by letting down cannon balls, &c., are less searching. The penetration does not go as far.

Material with 50 per cent. of voids in a considerable depth acts essentially as a liquid. It exerts the full lateral pressure corresponding to its height and weight per cubic foot, and when the resistance of the toe is overcome, this material moves forward and flows. Precise limits cannot be set, but this is the general result of observation at Calaveras as a result of determinations of voids in many samples of material that did flow and in other samples of material that did not flow. This refers to the Calaveras Dam* near San Francisco, Cal., which slipped as it was approaching completion on March 24, 1918, investigation of which afterward gave an unusual opportunity for studying some of the conditions that grew out of the methods of placing material that had been used. (*See* Figs. 4 to 6.)

Core material becomes solid when it is dried. Core material dried in the summer sun at Calaveras was consolidated until only 35 per cent. of voids remained. In this condition, it was only a little less strong and stable than the natural sandstone in the neighbouring hills.

Core material consolidated to 35 per cent. of voids would form the strongest and most stable kind of an earth dam. No large toes would be required to contain it, for on any reasonable slope it would be stable by itself. Such consolidation, however, as far as is known, is reached only by complete drying. Unfortunately, drying cannot be applied to the core of a large dam.

Without attempting precision of statement, it is the writer's judgment that if core material like that at Calaveras could be consolidated to 40 per cent. of voids, it would be sufficiently stable to do its share toward resisting the pressures that come upon the dam without tending to disruption. Perhaps this degree of stability would be reached before consolidation had proceeded as far as 40 per cent. of voids. There is a middle ground of uncertainty. Material with 50 per cent. of voids is still unstable; and between this limit and 40 per cent., one cannot be certain just where to draw the line.

FIG. 4. CALAVERAS DAM DURING CONSTRUCTION, SHOWING UPPER AND LOWER TOES, WITH POOL BETWEEN. WATER IN FOREGROUND IS IN RESERVOIR ABOVE DAM.

FIG. 5. CALAVERAS DAM DURING CONSTRUCTION, SHOWING TOES AND CENTRAL POOL A FEW DAYS BEFORE THE SLIP.

FIG. 6. CALAVERAS DAM AFTER THE SLIP. ON MARCH 24TH, 1918, 800,000 CUBIC YARDS OF MATERIAL MOVED 300 FEET UP STREAM AND DROPPED 100 FEET IN ELEVATION, TURNING ALSO 30 DEGREES TO THE RIGHT.

It is interesting to note that the 1¼-in. pipe used in the penetration tests only reaches to points where the material is still unstable. It follows that tests of this kind do not and cannot demonstrate stable material. Tests made by cannon balls or other less searching means are equally defective. It cannot be considered, in the light of the Calaveras experience, that tests made by such methods throw much light on conditions of stability. They may at times serve a purpose in showing lack of stability, but that is as far as use can be made of them.

It is the writer's thought that the best method of investigating consolidation and stability is by making borings. There are difficulties, for boring usually involves stopping the sluicing of material while the holes are being put down; but it does lead to more definite results. Borings can be driven and samples taken from the bottom of the borings for physical inspection and for determination of the percentage of voids.

(*To be continued.*)

* See *Engineering News-Record*, April 4, 1918, page 679 and December 26, 1918, page 1168.

A GERMAN INSTITUTE FOR CEMENT RESEARCH.—At the recent meeting of the Portland Cement Manufacturers in Heidelberg it was resolved to establish a general institute for cement research which would also devote itself to the interests of the two cognate bodies which supported the resolution, the Societies for Iron-Portland Cement and for Blast-Furnace Cements. Practically all the chief members of the staffs of the cement works being academically trained men, the resolution is sure to find general support, especially also in view of the fact that during the war American cement research has advanced to a leading position.

THE NEW YORK SHIPBUILDING CORPORATION.—We have received a capitally-written and well-illustrated pamphlet describing the history and development of the New York Shipbuilding Corporation, which is claimed to possess the largest self-contained shipbuilding plant now in existence. The works have developed from a yard laid out on the Delaware River in 1899 by the late Mr. H. G. Morse, who, it is stated, starting with a clean slate, determined to apply to shipbuilding the methods and appliances usual in bridge yards, all templets being made from the drawings direct without any fitting of them individually to the frames. Again all material was "routed" through the yard from reception to its final incorporation into the ship without back hauling. In addition, work was to be facilitated by the provisions of adequate crane facilities and by protecting the workmen from the weather. The scheme proved successful, and the templet methods of manufacture have been found applicable even to warships. Many of the templates it was found could be made of paper, thus effecting substantial savings, and the system has, it is stated, been copied by other yards. During the war great extensions were made, and on May 15 last 35 ships were actually in construction and eight more on order. Amongst these are two battleships of 32,600 tons displacement and a battle cruiser of 43,500 tons displacement.

TWO-STROKE CYCLE SEMI-DIESEL OIL ENGINE.

THE semi-Diesel and various forms of hot-bulb oil engine have been taken up so extensively by manufacturers, and we have illustrated so many types at one time and another that there may appear little new to be said about them. An engine of this class has, however recently been placed on the English market which incorporates many points of novelty. The engine, which is being manufactured by the Consolidated Pneumatic Tool Company, Limited, of Egyptian House, 170, Piccadilly, London, W. 1, and is known as the "Little Giant," is illustrated on page 378. A general view of the engine, which is of the two-stroke type, is given in Fig. 1, while a section showing the working parts is given in Fig. 2. This latter view clearly shows one of the special features of the engine, which lies in the fact that, instead of employing crank-case compression, it is fitted with a special compression chamber at the front end of the cylinder.

The engine, as will be seen, is of the horizontal type. This form of construction has been selected by the makers as it renders all important parts easily accessible. The piston can be withdrawn without trouble and the crankshaft lifted straight out after taking off the bearing caps. It is claimed that there is no tendency for the cylinder to wear oval since the adoption of the separate compression chamber allows of the piston rod being fitted with a crosshead working in a guide. This crosshead is an unusual feature in engines of this class and must be looked upon as one of the special features of the "Little Giant" engine. With regard to the compression chamber and the elimination of crank-case compression it is clear that the arrangement does away with the possibility of lubricating oil being burnt in the cylinder with resultant waste and bad governing, and allows of copious lubrication of the crank-pin and main bearings without waste of oil. The position of the crosshead and the compression chamber immediately at the front end of the cylinder can be seen in Fig. 2. The air compressed in the chamber passes to the cylinder by the passage which can be seen above the piston in Fig. 2, and the exhaust gases pass to the vertical pipe which can be seen below the cylinder.

The general lines of the construction of the bedplate can be seen from Fig. 2, while the cylinder casting is shown in Fig. 3. The water-jacket is cast integral with the cylinder and the cylinder head, also jacketted is a separate casting. The cylinder jacket, as can be seen in Fig. 2, covers only that portion of the cylinder in which combustion takes place. This is with the idea of eliminating unequal expansion. The bore of the cylinder is chilled hard and wears to a very fine polish in service. The cylinder head embodies another of the special features of the engine. As before stated, it is water-jacketted. The cylinder head, in addition, contains a combustion chamber fitted with a cast-iron liner which is kept hot by the heat of compression and combustion. The liner is separated from the cylinder by a water-jacketted wall through which there is a port leading into the cylinder to allow the pressure generated by combustion to act on the piston. The advantages claimed for this arrangement are that the hot liner is not subjected to bursting pressure nor is it liable to breakage from contraction and expansion. The hot liner also presents a large surface to the working fluid so that gasification is very rapid and it is possible to work with a later injection than is usual in the hot bulb engines. This lessens the likelihood of pre-ignition. The liner is of a cylindrical shape, and the oil as it is forced into the combustion chamber strikes the liner in such a way that it is instantly spread over its surface, gasified and ignited.

The piston is of cast-iron of trunk pattern, and as can be seen from Fig. 2, is provided with internal cooling ribs. This part of the piston is in contact with the cool air drawn into the compression chamber. A deflector on the head of the piston assists thorough scavenging at each stroke. The method of attaching the piston to the piston rod can also be seen in Fig. 2. A flange connector is secured to the end of the rod by a nut and dowel pin, and this connector is attached to the piston hub by four studs and nuts. The other end of the rod is screwed into the crosshead and locked with a nut. The crosshead is a single piece of semi-steel, and the connecting rod is a forging, with marine-type big end and gib and cotter at the small end. The crankshaft is fitted with counterweights secured by U-bolts passing round the crank webs. The main bearings are of some interest. For smaller engines they are of the diagonal type and so disposed that the thrust is concentrated on the cap. The idea of this is that in the unlikely event of fracture the cap is more easily replaced than the frame. For larger engine the type of bearing shown in Figs. 4 and 5 is used. The bearing is split diagonally and is adjusted by means of a wedge. As the thrust and consequently the wear is mainly on the adjustable half of the bearing, the taking up of wear by means of the wedge keeps the shaft practically in its original alignment. The design of the box is such that by taking the weight of the shaft, the bearings, which are of cast-iron lined with babbitt, may easily be removed.

The oil is injected into the cylinder by a positive plunger pump operated from an eccentric on the crankshaft. The plunger is a ground fit in the barrel and no packing is used. The valves consist of steel balls. A cam under the control of the governor rests against a collar on the plunger rod, and the position of the cam determines the stroke. A hand-operated lever, acting upon the same plunger, is provided for injecting the initial charge, or for cutting off the supply when stopping the engine. The oil is injected into the cylinder through a combined steel ball check valve and injection nozzle. This is illustrated in Figs. 6 and 7. The ball of the valve is held on its seat by a spring as shown. The valve admits oil into the cylinder, but does not allow the pressure due to combustion to be exerted back through the oil pump. The small opening of the nozzle causes the oil to be injected against the end of the liner at a high velocity, where it is broken up into a fine spray. It should be noted that injection takes place after the exhaust port is closed. The hot tube consists of a pipe nipple closed at the lower end with a cap and screwed into the lower side of the cylinder head directly under the opening in the liner. It is enclosed in a cast-iron hood and is heated by a blow lamp for starting. As the oil is injected against the head of the cold liner it drips down into the hot tube and is ignited. After starting and when the lamp is removed, the tube cools down to a black heat. The engine is fitted for water injection which enters through a check valve just above the port through which the pure air is transferred from the compression chamber to the cylinder. For single cylinder engines a hand-operated air starter can be supplied if desired and an automatic air starter for duplex engines.

NOTES ON NEW BOOKS.

THE close study given to structural details by American engineers is exemplified by this book, which has been specially prepared to meet the requirements of students and structural draughtsmen. Its title is "*Structural Drafting and the Design of Details*," its author Mr. Carlton Thomas Bishop, and its publisher Chapman and Hall, Limited, London (27*s.* 6*d.* net). It covers the preparation of detailed working drawings, and details of bridges, roofs, and buildings, in accordance with standard American practice, and a study of the principles laid down in this book will be most helpful to English draughtsmen in planning and arranging the layout of their drawings. The book is divided into three parts. Twenty-seven pages are devoted to Part I., which is introductory to the subject, and shows the relation between the drawing office and other branches of the steel industry. It describes the organization of the engineering department of a structural company, and the manufacture and fabrication of structural steel. Part II. deals with structural drafting, and in 186 pages the fundamentals of structural drafting are described in detail, and special emphasis is laid upon the methods of representation and dimensioning of all classes of structural work. In Part III, the elements of design are shown, with special reference to the design of details and simple members with which a draughtsman should be familiar. The general arrangement of the book is planned for convenient reference, and the shape of the book is such that it will lie open on the desk. The size of the pages allows the drawings to be made sufficiently large and clear without the use of folded insets.

The larger American pocket-books for engineers have a well-deserved reputation for supplying just the kind of information that will be valuable to workers remote from reference libraries, or isolated from fellow-craftsmen. They are, in short, not mere collections of formulas, but describe in considerable detail many phenomena and operations, which may, it is true, be commonplaces to the expert, but are by no means obvious to the young engineer who, far removed from possible help, is confronted with problems new to him if old in fact. Amongst these aids to the engineer, the "*American Civil Engineer's Pocket Book*," edited by Prof. Mansfield Merriman, of which a fourth and revised edition has just been published, takes a high place. The work is divided into sixteen sections, for each of which an expert on the subject-matter of the section has acted as responsible "associate" editor. Eighteen of these associated editors have been employed in preparing the new edition. The subject-matter covers practically the whole field of civil engineering as commonly understood, sections being given to railways, canals, highways, harbours, structural work, both in steel and concrete, water supply, sewerage, and irrigation works, whilst there is also a section on steam and electrical engineering. The whole of the text has been brought up to date, and added matter has necessitated a large increase in the number of pages, which now total 1,955, as compared with 1,580 in the third edition. The pocket-book, which is published in America by Messrs. John Wiley & Son's Inc., and here by Messrs. Chapman & Hall, Limited, is priced at 33*s.* net.

Tin-plate workers and manufacturers will welcome a set of tables of "*Rectangular Areas*," compiled by Mr. A. W. M. Elliott, and issued by Messrs. Scott, Greenwood & Son, of 8, Broadway, London, E.C.4, at the price of 7*s.* 6*d.* One table gives at sight the area in square inches of rectangles, ranging from 8¼ in. by 8¼ in. up to 54 in. by 28 in., advancing by quarters of an inch, and of other useful sizes up to 40 in. square. Supplemental tables provide corrections to be added when the dimensions of the rectangle of which the area is required are expressed in eighths or sixteenths.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Navigation.—Concern is felt among the manufacturing community at the necessity which may arise to close the Sheffield and South Yorkshire navigation undertaking. Increased charges for carriage have already been sanctioned, but it is doubtful whether these will leave a reasonable balance after the larger working expenses have been met. In the interests of local industry, the Ministry of Transport has been urged to intervene, and to sanction developments projected by the Sheffield Corporation in conjunction with district chambers of commerce for improving the canal by providing an up-to-date service to the East Coast.

Hull Coal Traffic.—Last month's tonnage sent from the South Yorkshire area was much greater than the total for August, 1919, owing to the strike then in operation. The respective figures were 229,925 tons, as against 97,791 tons. This year's aggregate, 1,502,519 tons, is about 140,000 tons more than was sent during the first eight months of 1919. Of the quantity last month exported, 21,830 tons, Denmark took 8,611 tons, Sweden 4,304 tons, and France 3,275 tons. Grimethorpe and Frickley collieries were the largest contributors, with 28,951 tons.

Iron and Steel.—The general feeling of uncertainty and insecurity respecting the labour position, is militating with increased severity against the progress of home and overseas business in all classes of steel products, but particularly in regard to heavy engineering. Buyers are not disposed to enter into forward bookings without definite stipulations as to price, and these stipulations producers are unable to give until they get some reasonable indication of the likely changes in wages movements. It is generally admitted that winter trade will suffer seriously if the labour position does not quickly become more stabilised. An important development is that the turning point in prices of certain basic materials appears definitely to have been reached. Following increased offers by United States and Belgian producers, the official basis of soft steel billets has been reduced 2*l.* per ton to 23*l.* 10*s.*, and high carbon billets 1*l.* to 25*l.* 10*s.* In sympathy, soft steel rods have declined 5*l.* per ton to 30*l.* This downward movement, however, has not yet touched the better grades of steel. On the contrary, acid and hard basic qualities are quoted 15*s.* to 1*l.* a ton higher to cover enhanced transport charges. There is little movement in machinery or structural steel. Instances of short-time working are rare, but the projected lock-out of electricians is inevitably lessening production and delaying deliveries. Concurrently, orders for light steel are beginning to diminish, though the tool branches have a big weight of arrears to work off.

South Yorkshire Coal Trade.—Doncaster races were the cause of a big slump in production. Widespread absenteeism among the miners resulted in most of the pits in this district being set down two to three days. Consequent dislocation of industry was considerable, manufacturers having to draw on emergency stocks to keep works running. Collieries are now working under pressure to bring contract commitments up to date. The demand for best steam hards and for gas fuels is more than equal to the gross output. Cobbles, nuts and slacks are all firmly held at maximum prices. The house coal position locally is slightly easier, though pressure is being brought to bear upon collieries to increase deliveries to London and the South. Quotations: Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The crisis in the coal trade is holding up business. Producers of Cleveland pig-iron have rather considerable stocks of mottled and white qualities which they are now prepared to offer for shipment abroad, but on what terms definite information is not to hand. It was hoped that the embargo on export of foundry pig-iron and silicious iron might have been removed this week, but makers have decided not to take such a step in face of the fact that

output is still insufficient to fully cope with home needs. The feeling, however, prevails that it will not be long before the better grades of Cleveland pig-iron will once more be available for despatch to foreign customers. Belgium and Germany are supplying markets abroad which were hitherto customers of this district. To home customers, No. 3 and the common kinds of Cleveland pig-iron are 225*s.*, and No. 1 is 237*s.* 6*d.*

Hematite Iron.—The East Coast hematite branch is lifeless, and the outlook is not at all encouraging. Home consumers are off the market, having covered their requirements, and inquiries on foreign account are now very few and small, many Continental customers, in fact, being anxious to cancel contracts recently made. For home purposes, Nos. 1, 2 and 3 are put at 260*s.*, and No. 1 is quoted 262*s.* 6*d.*; whilst for shipment to France, Belgium and Italy mixed Nos. are 265*s.*, and No. 1 is 267*s.* 6*d.*

Foreign Ore.—As yet there is little passing in foreign ore, but consumers are much more disposed to listen to sellers' offers. The latter are keen to operate and are offering to sell up to the end of March next. Market quotations may be given as equal to 47*s.* 6*d.* c.i.f. Tees for rubio, of 50 per cent. quality, though possibly business might be done on slightly lower terms. The freight Bilbao-Middlesbrough, varies from 17*s.* to 17*s.* 3*d.*

Coke.—There is little or nothing passing in coke. Export transactions are impossible, and supply for home purposes is rather short, complaint being heard that deliveries to some of the local blast furnaces is barely sufficient to meet essential needs. Average furnace coke is 62*s.* 9*d.* at the ovens, and quality low in phosphorus is 65*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—Business in finished iron and steel is almost at a standstill. Belgium and America are not only underselling this district abroad, but they are competing successfully in home markets, and it is at least doubtful whether our present high rates can be upheld. The opinion is rather freely expressed that buying here, on anything like an extensive scale, will not be experienced until prices have been reduced. The following are among the principal market quotations:—Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.* steel joists, 24*l.*; steel boiler plates, 31*l.*; soft steel billets, 23*l.* 10*s.*; heavy sections of steel rails, 25*l.*; fish plates, 30*l.*; black sheets, 38*l.*; and corrugated galvanised sheets, 44*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The past week has seen little change in the position of the Scotch steel trade and things are very similar to what they have been during recent weeks. Inquiry is still very small and is not expected to increase in the meantime, and little improvement can be looked for until the many labour troubles of the present are nearer solution. Unrest is very general throughout the country, and that is retarding new business. Steelmakers' books show many orders still to work off and they are thus in a very happy position just now. The demand for ship plates is good and the Clyde yards alone are consuming enormous quantities so that there are no stocks whatever at makers' works. In the matter of sectional material the activity is not so pronounced, and regular buyers can get their demands executed more quickly. Makers of black sheets are as busy as ever and have so much work booked that it will be a considerable time before they can entertain fresh orders for anything like prompt delivery. Galvanised sheets are also fairly active at the moment with a good export inquiry. The shipping side of the industry has not improved, but with the home trade still demanding the bulk of the output of steel there is nothing much left over. Prices are unchanged, and while a shade less firm, have not been officially altered.

Malleable Iron Trade.—The West of Scotland malleable iron trade is again a little easier, and although the works are all fully employed and the home trade is taking up the bulk of the output, there is not so heavy pressure for deliveries. Inquiry from abroad is fairly good and producers are giving it a little more consideration than heretofore. Prices rule steady.

Scotch Pig-Iron Trade.—A firm tone characterises the Scotch pig-iron market, and employment at the different works is very steady. The scarcity of foundry and hematite iron is still rather pronounced, but with better and more regular supplies of ore the outlook is improving and the shipping departments are becoming more active. Deliveries all round are quite good, but they still fall far behind the actual requirements of consumers, although there are prospects of all arrears being wiped off at no distant date. Prices rule firm, but no change has been made despite the extra costs of carriage and the fact that south country iron has been advanced in price. The export trade is better, and developments in that direction may be looked for before long.

The Outlook.—The industrial outlook is no brighter and is, in fact, far too clouded to be satisfactory from any point of view. At the present moment the trouble in the coal-mining industry overshadows everything else as it means so much to everybody. Should a strike take place trade will very soon be paralysed because so few establishments have any decent stock of fuel. In the iron and steel trades a general stoppage is highly probable, as available supplies could only be made to spin out a very few days. The uncertainty of the outlook is having its effect on inquiries both home and foreign, and buyers are holding off the market and are just marking time. Dear fuel cannot permit of easier prices, no one anticipates coal becoming any dearer, but buyers contend that the high prices of the present time cannot continue if trade becomes slack and that we are fast approaching that state. What is really wanted is labour to settle down and increase the output all round and then to ask for some recompense for the higher production.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The outlook remains very gloomy, but many are still of the opinion that a national stoppage of colliery workers will be averted. The provisional estimate of the financial results of the working of the coal mines for the quarter ended June, issued by the Government, has to a large extent taken the wind out of the sails of the miners' case, for it is shown that compared with the March returns the output at 58,144,000 tons in the June quarter shows a reduction of 3,913,000 tons, while the net costs have increased from 29*s.* 4·94*d.* to 36*s.* 7·3*d.*, of which wages alone absorbed 25*s.* 5·72*d.*, against 22*s.* 8·50*d.* in the March quarter. The credit balance amounts to only 7,908,041*l.*, against 14,377,072*l.*, or at the rate of 31,632,000*l.* per annum. The claim of the miners for a 14*s.* 2*d.* per ton reduction in the price of house coal and a flat-rate wage increase of 2*s.* per shift for adults is based on a total profit of 66,000,000*l.* a year, and thus the financial results for the second quarter of the year are entirely against the miners notwithstanding their contention that the output in the past quarter was lower because of holidays and expenditure abnormally heavy in connection with development and maintenance work, which would in due course benefit the owners. Assuming these contentions to be accurate the expenditure on development would also benefit the men, for increased production would automatically increase the earning power of the workers and also enable the owners to dispose of the coal at a lower price. Meanwhile new business remains practically at a standstill as the home and bunkering demands absorb almost the whole of current outputs, while collieries in the majority of cases are so heavily stemmed that they cannot take on fresh commitments. Prices in the circumstances are more or less nominal at 115*s.* for large, 110*s.* throughs and 95*s.* for smalls. Foreign exports in the past week totalled 254,204 tons, of which 103,573 tons went to France, 28,782 tons to Italy, 14,108 tons to Spain, 17,867 tons to Portugal 69,234 tons to British coaling depots, and 20,640 tons to other countries. Strike notices have been tendered by the majority of the miners, though it is reported that a large number have not handed in their notices and, assuming a stoppage takes place, much interest is evinced as to whether those who have not handed in their notices will come out with the majority.

Cardiff Shipping Firm Winding-Up.—Meetings of the Field Line (Cardiff), Limited, have been convened to consider proposals for voluntarily winding-up and the distribution of the assets amongst the shareholders. The ordinary share capital of the company is 54,343*l.* and the assets 300,936*l.*, which, after the payment of a lump sum of 45,000*l.* to the managers as compensation and 5,000*l.* to the directors, is estimated to admit of the payment of 4*l.* for each 1*l.* share. The company at one time owned five steamers, three of which were sold and two sunk by enemy action. During the past 8½ years dividends totalling 115 per cent., free of tax, have been distributed.

THE PATENT OFFICE LIBRARY.—The Patent Office Library is open to the public daily except on Sundays, Good Friday, Christmas Day, Whitsun Eve and Bank Holidays. On and after October 1, 1920, the hours of opening will be from 10 a.m. to 9 p.m., except on Christmas Eve and Easter Eve, when the library is closed at 4 p.m.

MIDDLESBROUGH PIG-IRON SHIPMENTS.—Statistics issued by Messrs. William Jacks and Co., 5, East India-avenue, E.C., show that the shipments of pig-iron from Middlesbrough, including Skinningrove were, last April, 23,270 tons coastwise and 4,975 tons foreign, a total of 28,252 tons, as compared with 23,856 tons in August, 1919, and 48,593 tons in August, 1918. Last August there was a great falling-off in shipments to France Belgium, Norway and Sweden, and no shipments to America, Canada and Italy.

REINFORCED LEAD.—As lead suspended in large sheets is liable to sag or creep, special supports for heavy lead plating are provided in sulphuric acid chambers, oil-refining kettles and pulp digesters, &c. C. Baskerville and C. M. Wales reinforce the lead, after the manner of concrete, by wire gauge or perforated iron sheets. By this patented process they claim (*Chemical and Metallurgical Engineering*, June 9 last, page 1081) to increase the tensile strength of the metal two or three times and the elastic limit four or five times. When manufactured the sheets may be rough, and they are then smoothed by rolling; the rolling also expands the sheets longitudinally and laterally by 20 per cent. or more. The reinforced sheets may be bent and can be joined by burning. To make lead pipes from reinforced sheet lead, the lead is melted off the edges, and the edges are then burned together. An 8-in. pipe, of reinforced lead 2·0 in. thick, collapsed at a pressure of 85 lb. per square inch.

NOTICES OF MEETINGS.

THE IRON AND STEEL INSTITUTE.—Tuesday, September 21, at 10 a.m., at the South Wales Institute of Engineers, Cardiff, General Meeting of members. The following papers will be read and discussed: "The Electrification of the Works and Collieries of the Ebbw Vale Steel, Iron and Coal Company, Limited," by Mr. W. Dixon; "Inter-Crystalline Fracture in Mild Steel," by Dr. W. Rosenhain and Mr. D. Hanson; "The Constitution of Nickel-Iron Alloys," by Mr. D. Hanson and Mrs. Hilda E. Hanson. In the afternoon, visit to Dowlais Cardiff Works and Bute Docks. Wednesday, September 22, at 9.30 a.m., General Meeting of members. The following papers will be read and discussed: "The Rough Cleaning of Blast-Furnace Gas at Skinningrove by the Lodge Electrostatic Process," by Mr. A. Hutchinson and Mr. E. Bury; "Variations in the Heat Supplied to the Blast Furnace, and their Effect on the Fuel Consumption," by Mr. W. W. Hollings; "Electric Steels," by Mr. C. G. Carlisle. Eight other papers have been sent in. In the afternoon, visit to Alexandra Docks and Barry Docks. Thursday, September 23, visit to Ebbw Vale Works and to Chepstow, Friday, September 24, visit to Port Talbot and to works at Swansea.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, September 23, at Caxton Hall, Westminster, when the president, Mr. W. Pickersgill, C.B.E., locomotive engineer, Caledonian Railway, will deliver his address. The chair will be taken by Mr. A. J. Hill, C.B.E., past-president, at 7.30 p.m. By permission of Mr. A. J. Hill, C.B.E., chief mechanical engineer, Great Eastern Railway, the members of this Institution will also visit the Stratford works on Thursday, September 23. The members will assemble at the works entrance at 2.15 p.m.

WIRELESS TELEGRAPHY AND SWEDISH SHIPS.—The obligation to carry a wireless telegraph apparatus which is prescribed by the British Merchant Shipping Wireless Telegraph Act on all vessels over 1,600 tons, has aroused uneasiness in Swedish shipping circles owing to the fact that, in view of the present conditions of the labour market, it may often be difficult or impossible to procure wireless telegraph apparatus and to train telegraphists. The Swedish General Shipping Association, according to *Swedish Export*, has therefore petitioned the Minister for the Navy to make a request to the British authorities that Swedish shipowners who can show that their efforts to fulfil the requirements of the law have encountered insuperable difficulties, shall be dispensed until the end of 1921 from this obligation.

FUEL ECONOMY AND THE TRAINING OF STOKERS.—The seriousness of the fuel problem in Germany has led to the creation of several new institutions to promote research and training and to facilitate general economy. The Coal Council is to act as a medium for the exchange of information. The Heat Station established at Düsseldorf by the Iron Metallurgists with a branch at Kattowitz (Silesia) trains experts to supervise the economical utilisation of heat in large metallurgical works; the special heat engineer at the works has nothing to do with the regular operations, but has simply to control the heat balance. Such heat stations are now being established also for the textile, leather and brewing industries. Various stoker courses have been started. The first course of three weeks' instruction was given at Essen in June, the arrangements being made by the Steam Boiler Supervision Association in conjunction with other bodies. The number of stokers attending was limited to 50 each for the theoretical and practical course, but 100 had to be admitted to each of these two courses; they were divided into groups. Six collieries and the Rhenish-Westphalian Electricity Works placed their plants at the disposal of the committee. The first idea had been to train stokers. In view of the large numbers of ordinary stokers the course was adapted to the training of chief stokers who, in their turn, will train the stokers in their works.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—A report, No. 131—1920, has been issued by the British Engineering Standards Association dealing with the standardisation of test-pieces for the notched bar test. The subject of the report has engaged the attention of the association for some considerable time past and the committee, which has been under the chairmanship of Dr. W. Cawthorne Unwin, has had the benefit of much experimental and research work carried out at the National Physical Laboratory with funds provided by the Department of Scientific and Industrial Research. The Aeronautical Inspection Department of the Air Ministry has also co-operated, as well as a number of manufacturers, including Sir Robert Hadfield, Bart. The report commences with a short description of the usual methods adopted for fracturing the test-piece, useful notes and data being given of the principal machines used in these tests, viz., Charpy, Izod, Frémont, Amsler and Guillery. The actual form of notch is dealt with and dimensions are recommended for the British Standard test-pieces and for subsidiary standard test-pieces of smaller cross-section for use when the former cannot conveniently be obtained. The report concludes with a valuable series of plates illustrating to scale the various test-pieces dealt with, the direction and point of impact of the pendulum or falling weight of the testing machine and grips for holding the test pieces. The report can be obtained from the Secretary of the Association, 28, Victoria-street, S.W. 1, Price 1*s.* 2*d.* post free.

TWO-STROKE CYCLE SEMI-DIESEL OIL ENGINE.

CONSTRUCTED BY THE CONSOLIDATED PNEUMATIC TOOL COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 376.)

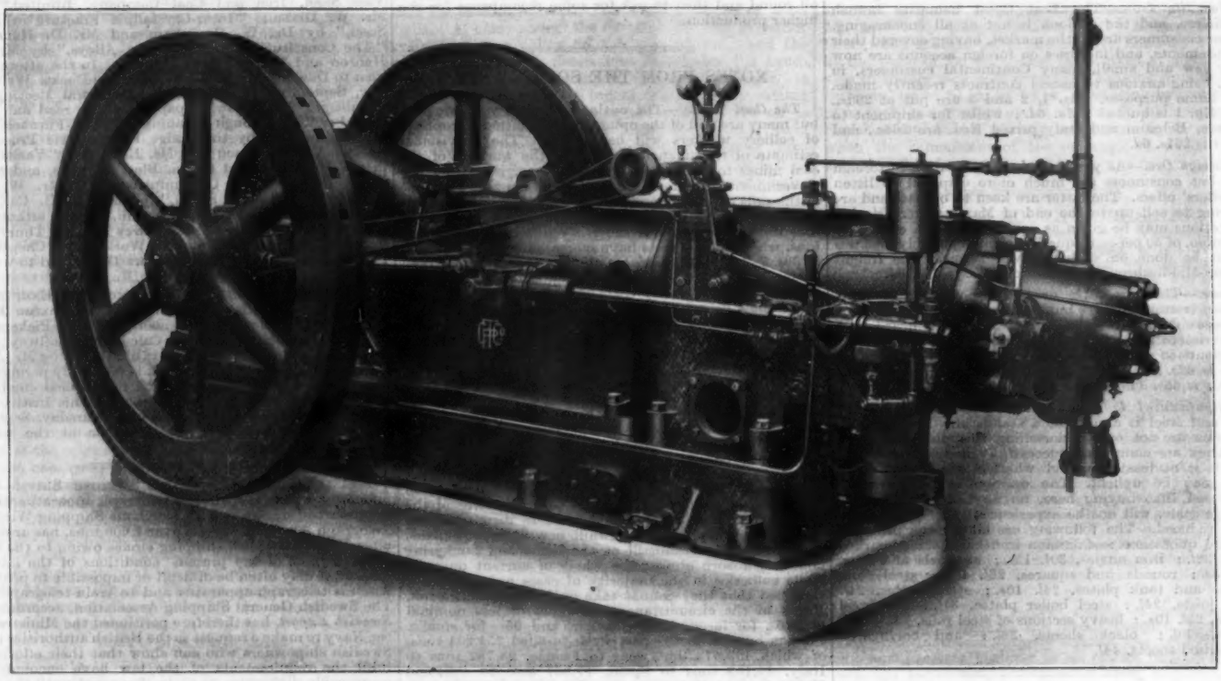


FIG. 1.

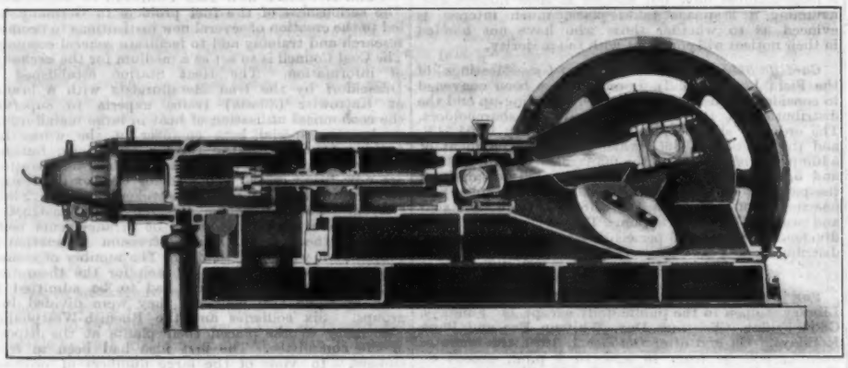


FIG. 2.

Fig. 4.

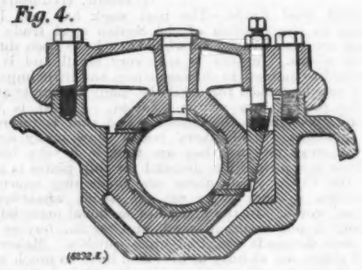


Fig. 5.

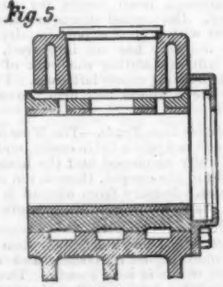


Fig. 6. OIL INJECTION NOZZLE.

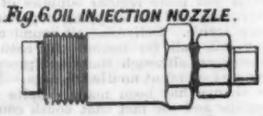


Fig. 7.

THE POLYTECHNIC, REGENT-STREET.—This Institution has issued pamphlets giving particulars of classes or courses of instruction which have been arranged for the forthcoming session, commencing on Monday, September 27. The heads of the various departments will be in attendance from September 15 to 17, and from September 20 to 24, between 6 p.m. and 8.30 p.m., in order to advise intending students in the selection of classes.

THE "ALWAZOT" HEAT REGULATOR.—This device has been put upon the market by Bell's Hot Water Syndicate, Limited, Donington House, Norfolk-street, Strand, W.C. 2, for fitting into hot water tanks for obtaining a regular supply of hot water in dwelling houses &c. The regulator contains a valve opened or closed by changes of temperature. It is located wholly inside the hot-water tank. A vertical pipe rises from the regulator and reaches close to the top of the tank. The body of the regulator forms the "mixing chamber." This is continued outside the hot-water tank by a vertical hot water supply pipe which forms part of the hot water distribution system, and ultimately leads back to the range or boiler and thence again to the tank, thus establishing a circuit; on this latter hot water supply pipe is branched the hot water supply tap. The "mixing chamber" contains a simple flat brass valve which rests on its seating by its own weight and is under the action of a "curling strip"; the strip bends or flattens out with the varying temperature of the moving water, and allows only as much water to circulate as the heating service can deal with. When hot water is drawn off, the entrance of fresh cold water into the circulating system is governed by the action of the regulator, the hotter water being first drawn off from the top of the tank, and cold only admitted through the valve as the temperature of the whole falls. The device yields hot water in a much shorter time after lighting the fire than do the ordinary arrangements.

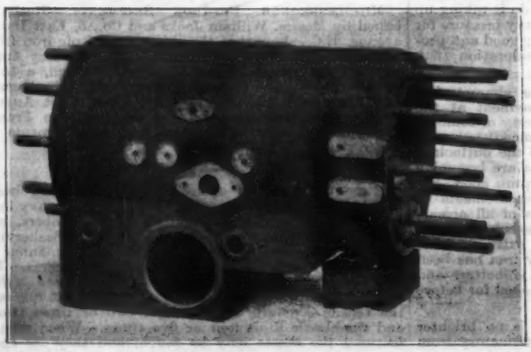
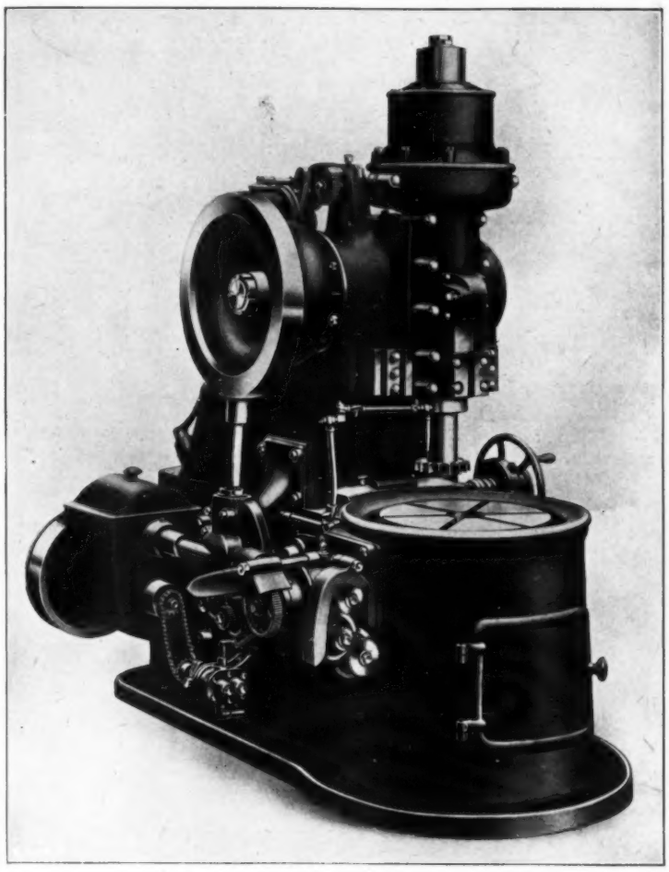
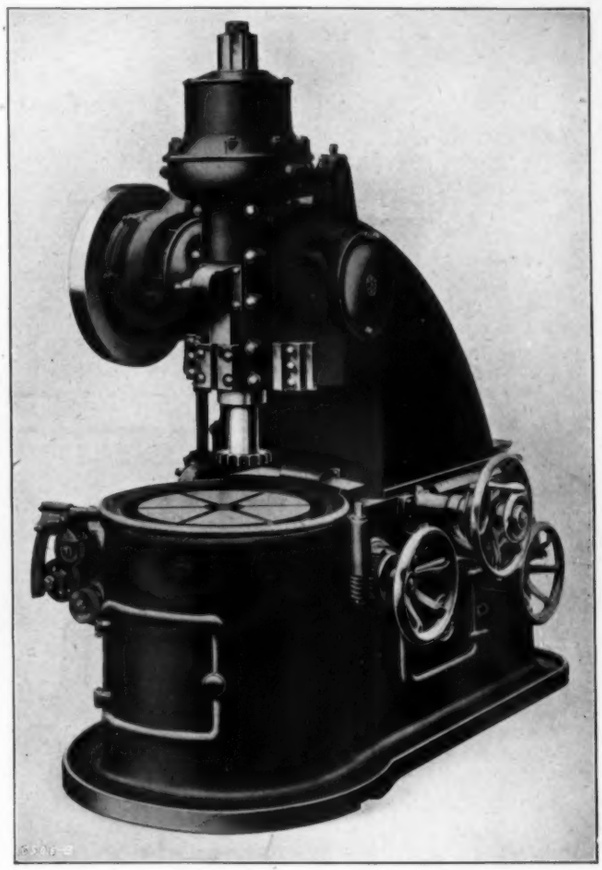


FIG. 3.

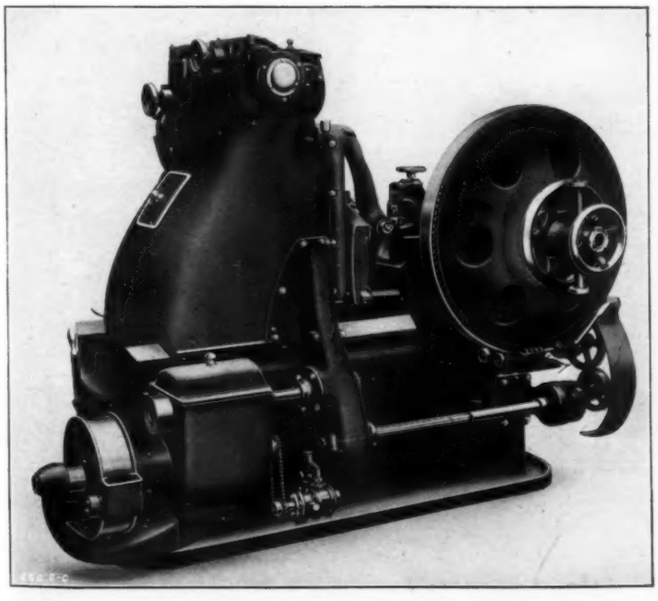
THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

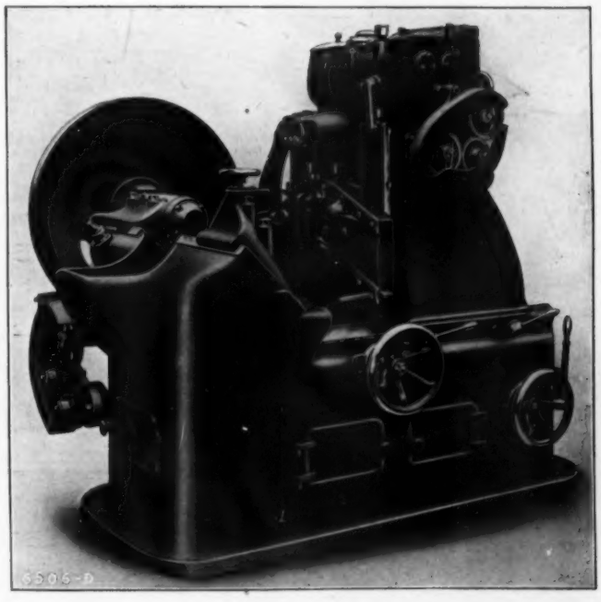
(*For Description, see Page* 363.)





FIGS. 108 AND 109. SPUR GEAR GENERATOR; MESSRS. DAVID BROWN AND SONS (HUDD.) LTD.





FIGS. 110 AND 111. DOUBLE HELICAL GEAR GENERATOR; MESSRS. DAVID BROWN AND SONS (HUDD.) LTD.

(*To face page* 364.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 363.)

Fig. 112.

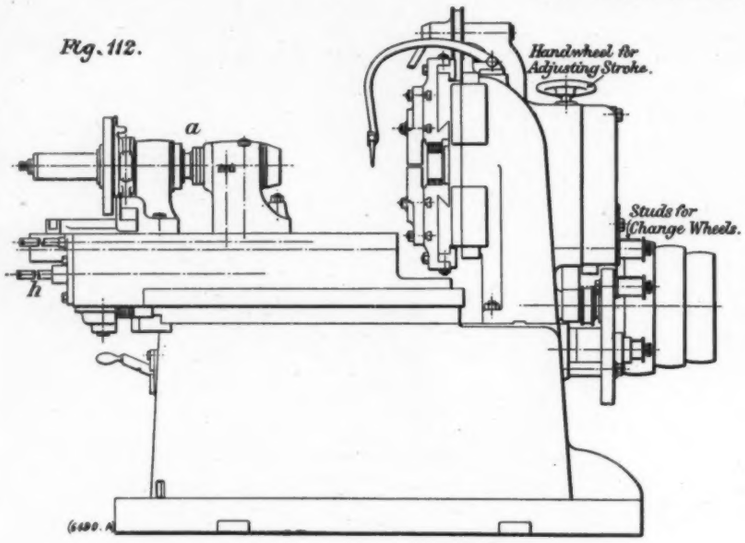


Fig. 113.

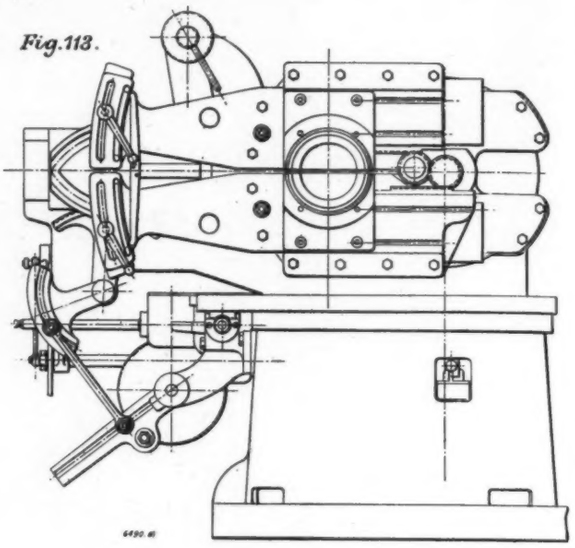


Fig. 114.

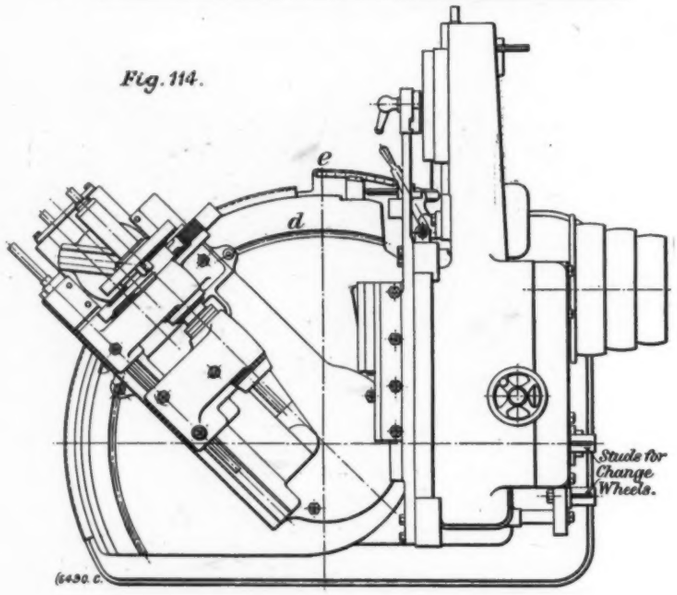


Fig. 115.

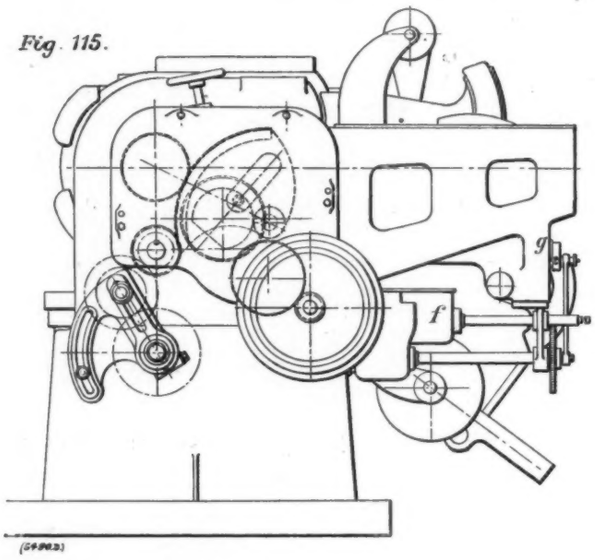
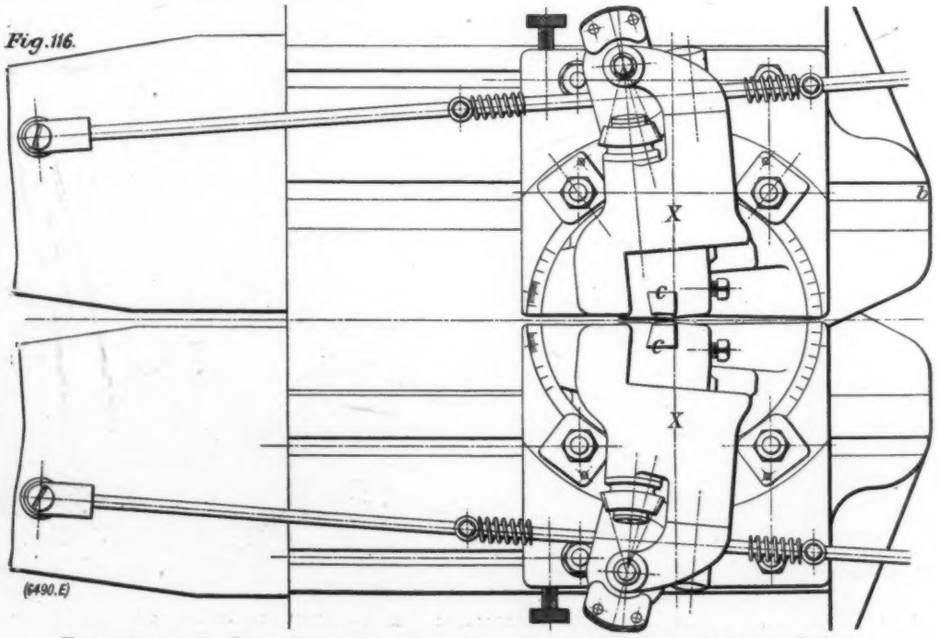


Fig. 116.



FIGS. 112 TO 116. SPIRAL-BEVEL GEAR GENERATOR; MESSRS. SMITH AND COVENTRY, LIMITED.

(*To face page* 365.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 363.)

Fig. 119.

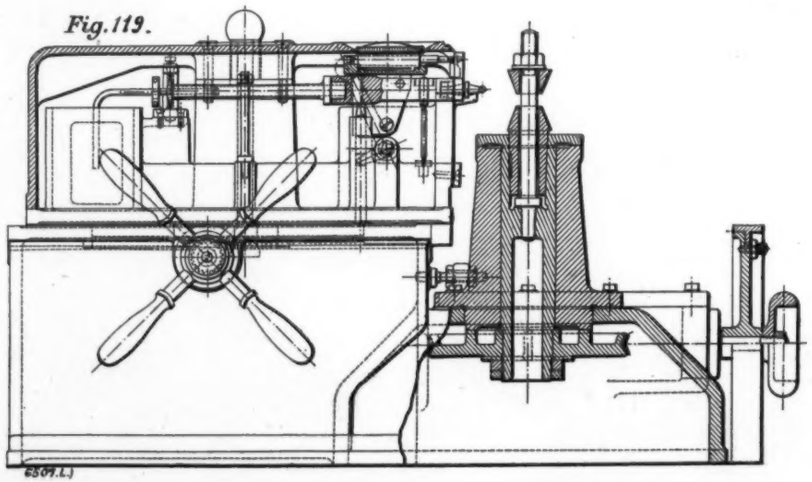


Fig. 120.

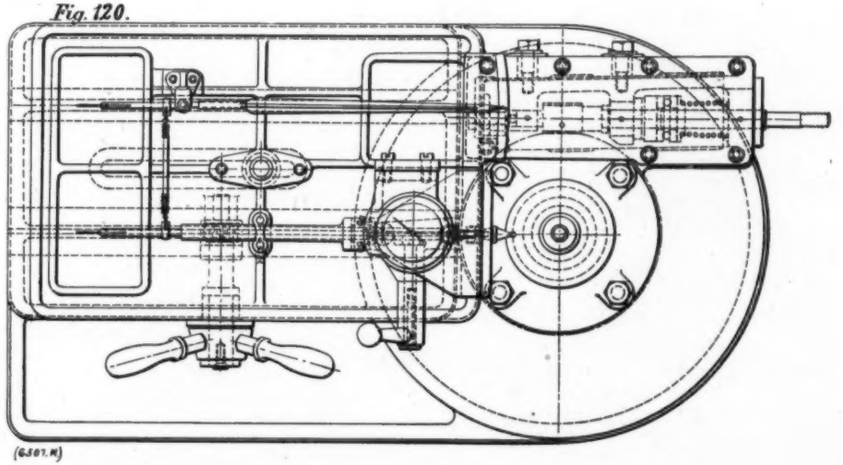


FIG. 121.

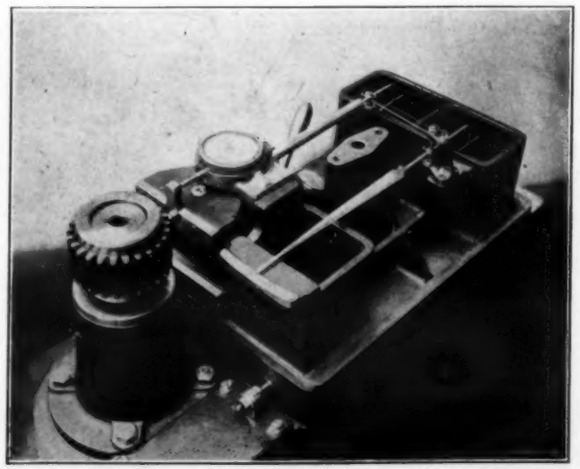


FIG. 122.

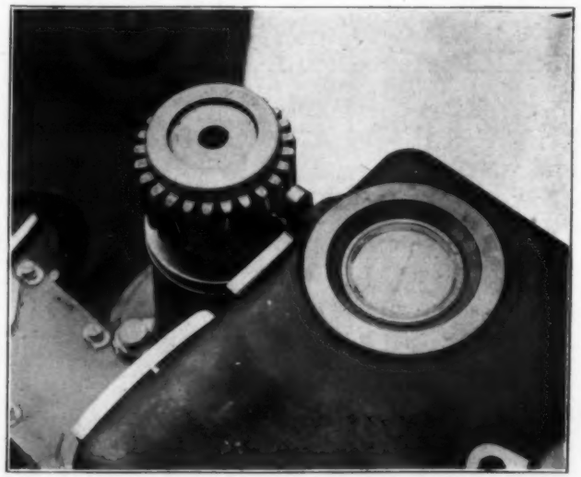


FIG. 123.

FIGS. 119 TO 123. WICKMAN GEAR PITCH AND CONCENTRICITY MEASURING MACHINE; MESSRS. THE COVENTRY GAUGE AND TOOL CO., LTD.

(*To face page* 366.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

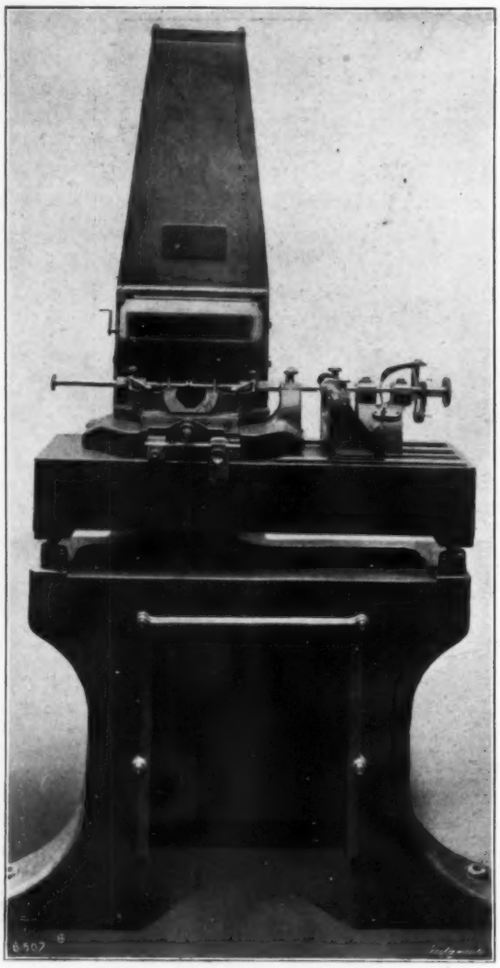


FIG. 125. WICKMAN UNIVERSAL GAUGE MEASURING MACHINE; MESSRS. THE COVENTRY GAUGE AND TOOL CO., LTD.

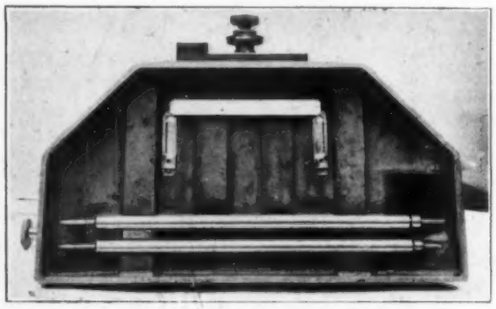


FIG. 127. UNDERSIDE OF CARRIAGE SHOWING SUPPORTS.

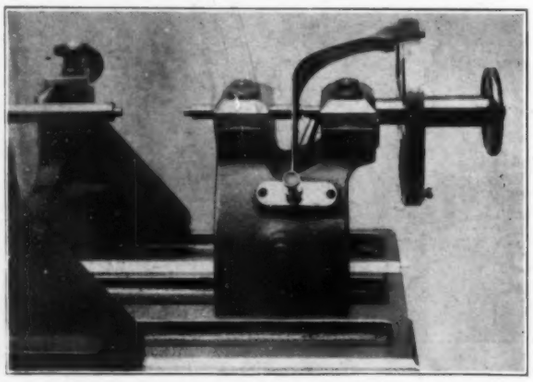


FIG. 129. MICROMETER AND VERNIER CORRECTOR

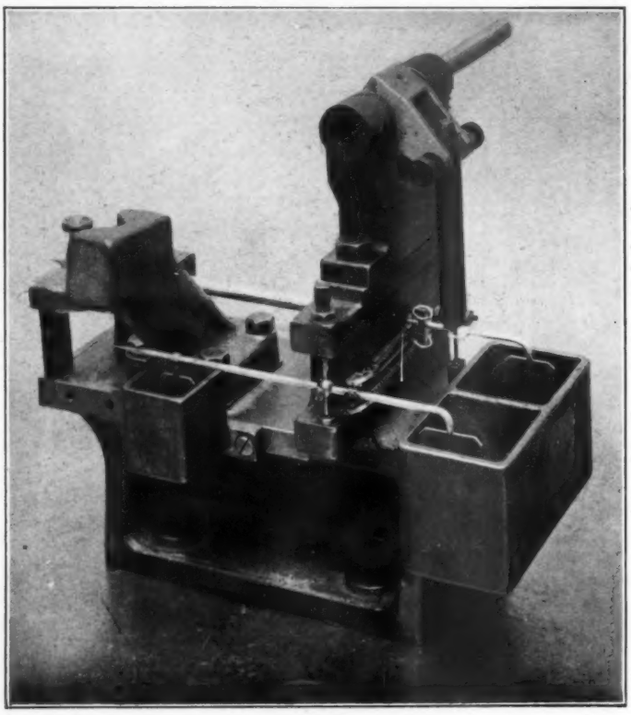


FIG. 126. STYLUS AND MECHANICAL MAGNIFYING GEAR.

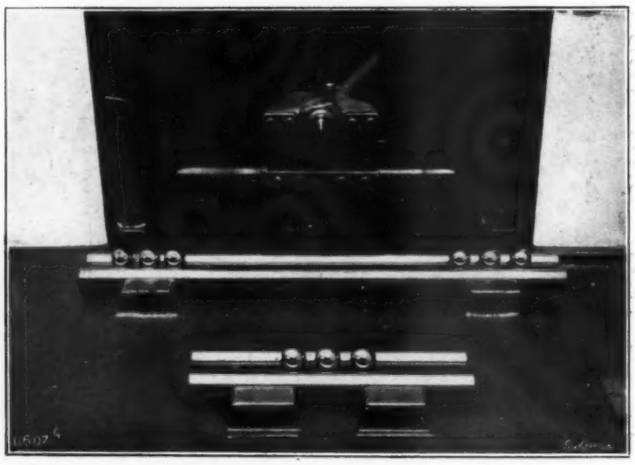


FIG. 128. VIEW SHOWING SUPPORTS FOR CARRIAGE AND STYLUS.

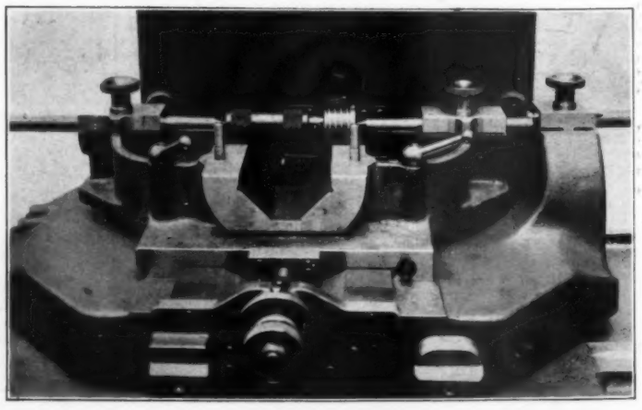
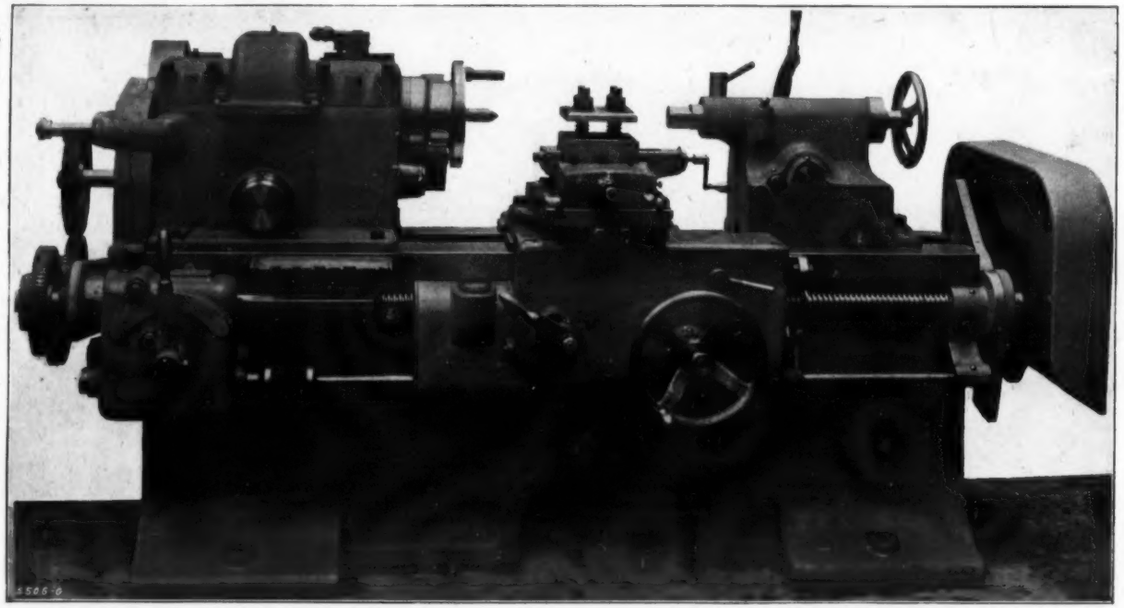


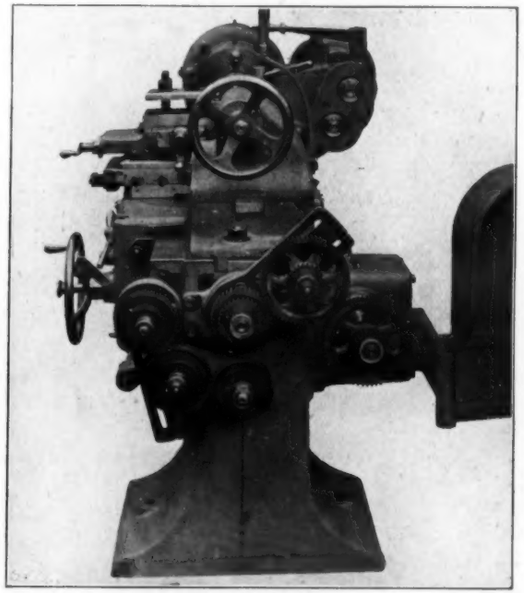
FIG. 130. CARRIAGE WITH SCREW GAUGE, MOUNTED FOR PITCH MEASUREMENT.

(*To face page* 367.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 363.)





FIGS. 134 AND 135. RELIEVING LATHE; MESSRS. WARD, HAGGAS AND SMITH.

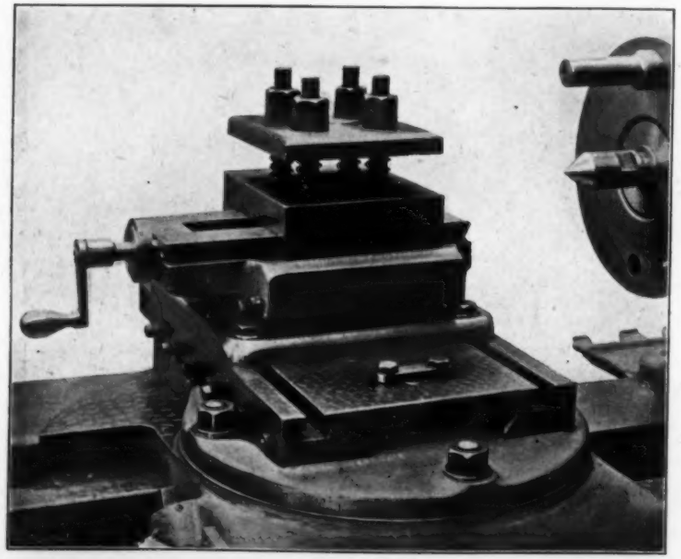


FIG. 136. SADDLE OF WARD, HAGGAS AND SMITH RELIEVING LATHE.

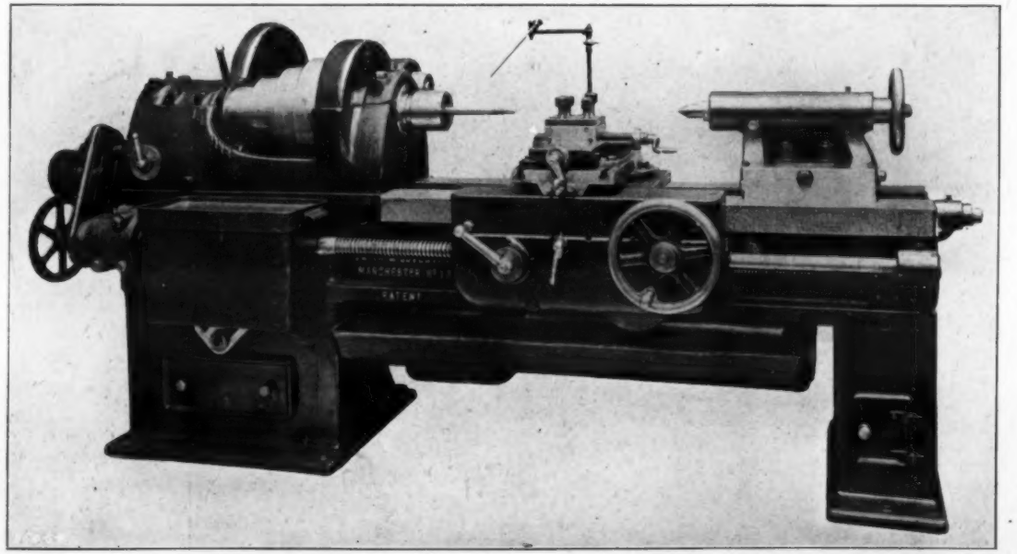


FIG. 137. RELIEVING LATHE; MESSRS. SMITH AND COVENTRY, LTD.

(*To face page* 368.)

THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 363.)

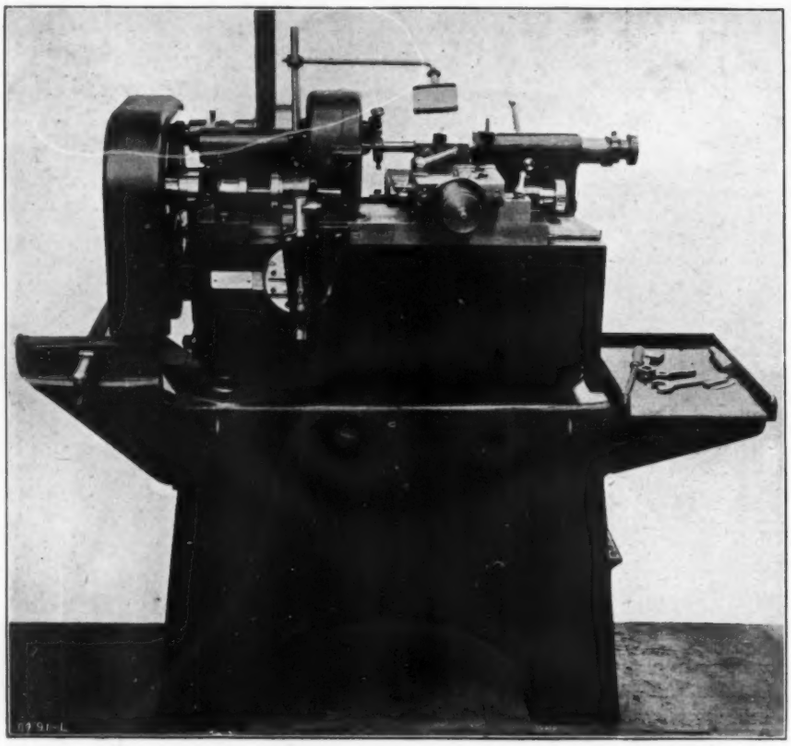


FIG. 141. PRECISION SCREW LATHE; MESSRS. ALFRED HERBERT, LTD.

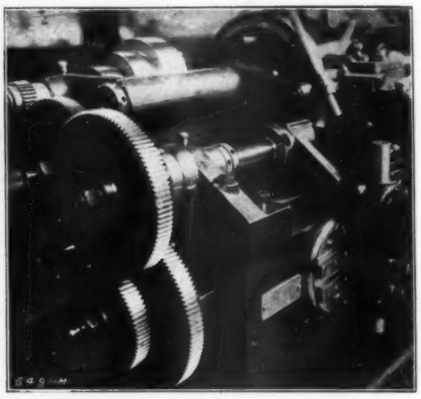


FIG. 142. PITCH CORRECTOR; HERBERT PRECISION SCREW LATHE.

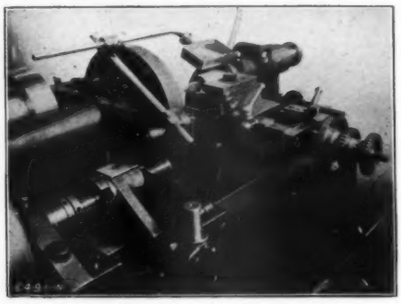
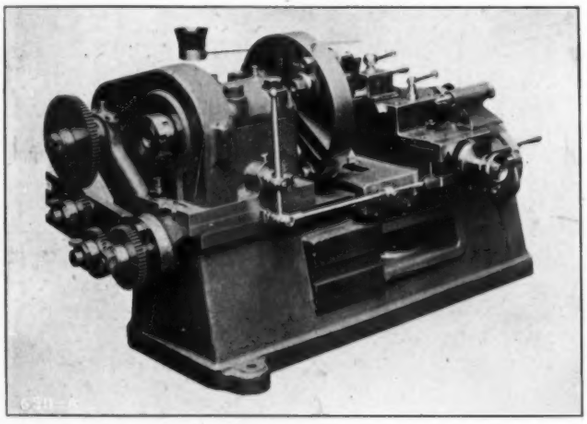
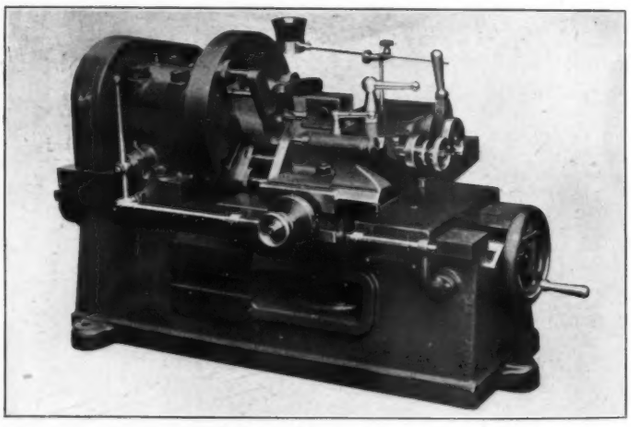


FIG. 143. SADDLE OF HERBERT PRECISION SCREW LATHE.





FIGS. 144 AND 145. INTERNAL PRECISION SCREW LATHE; MESSRS. BRYANT SYMONS AND CO.

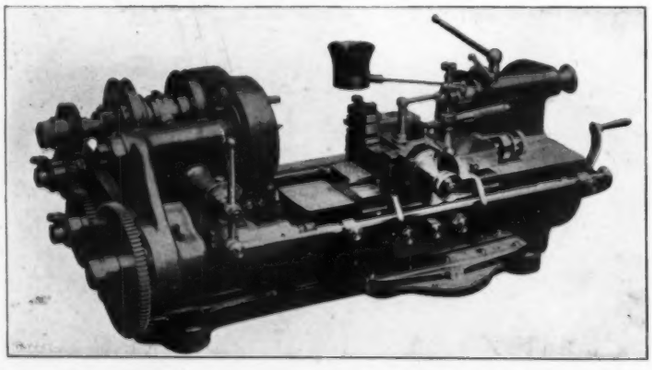


FIG. 146. EXTERNAL PRECISION SCREW LATHE; MESSRS. BRYANT SYMONS AND CO.

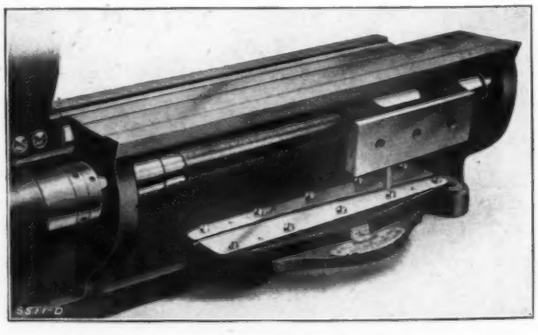


FIG. 147. PITCH CORRECTOR; BRYANT SYMONS PRECISION SCREW LATHE.

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THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

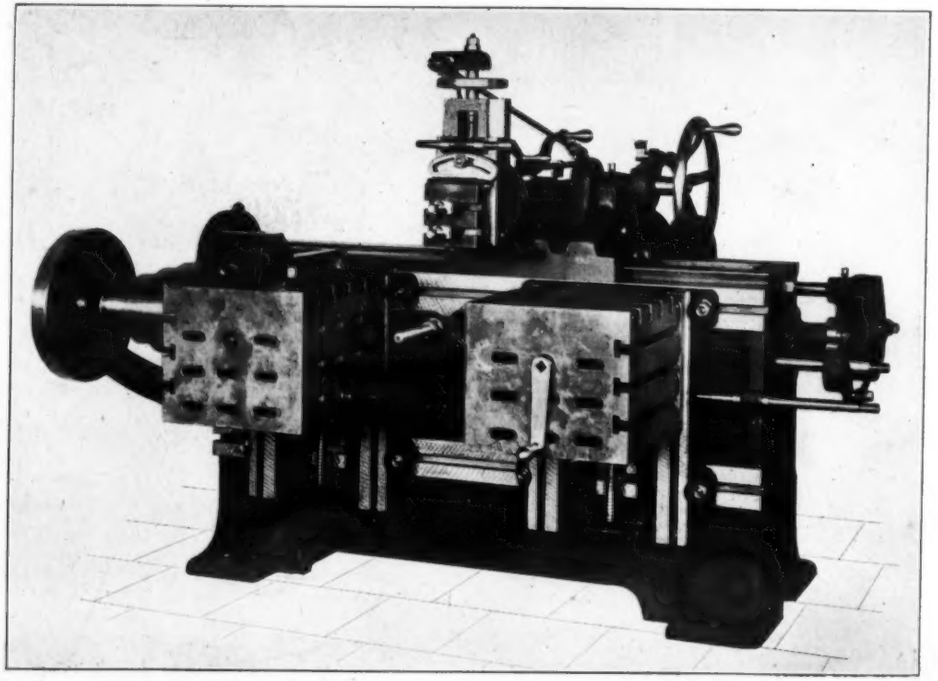


FIG. 154. 14-IN. TO 16-IN. TRAVELLING HEAD SHAPER; MESSRS. THE ROBSON MACHINE TOOL CO., LTD.

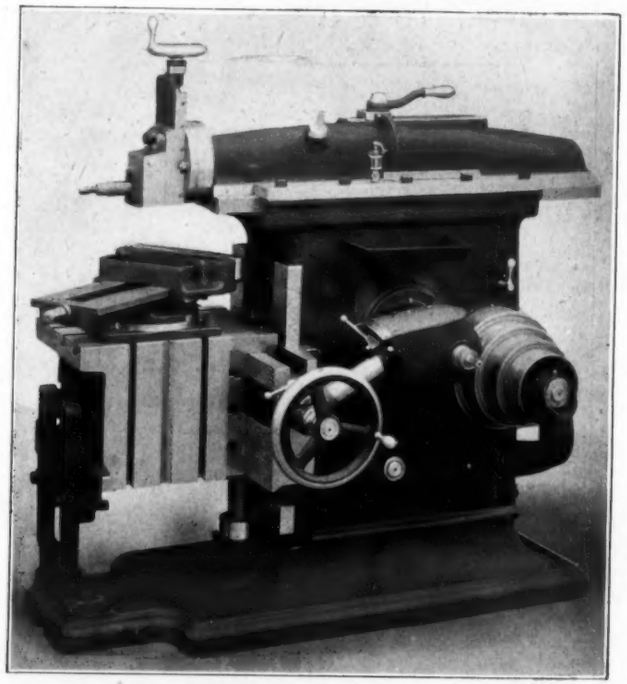


FIG. 155. 24-IN. SHAPER; MESSRS. THE QUEEN CITY MACHINE TOOL CO.

Fig. 156.

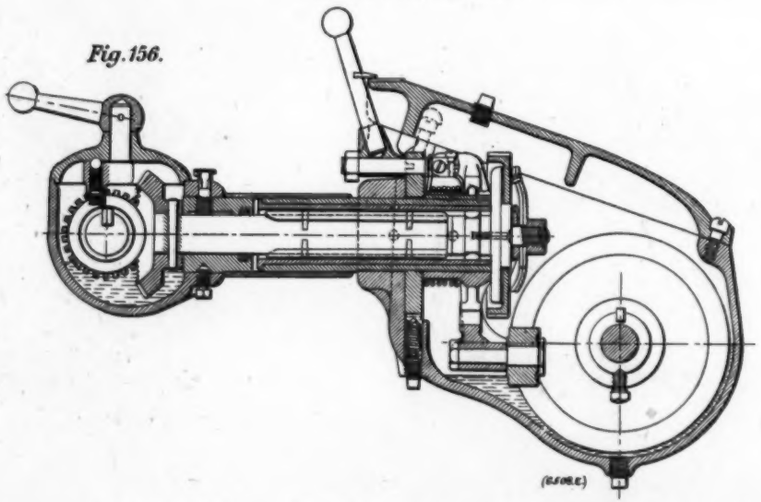
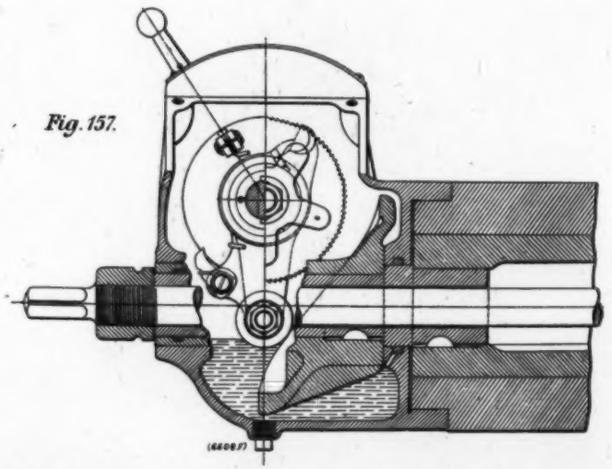


Fig. 157.



FIGS. 156 AND 157. DETAILS OF QUEEN CITY SHAPER.

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THE MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 363.)

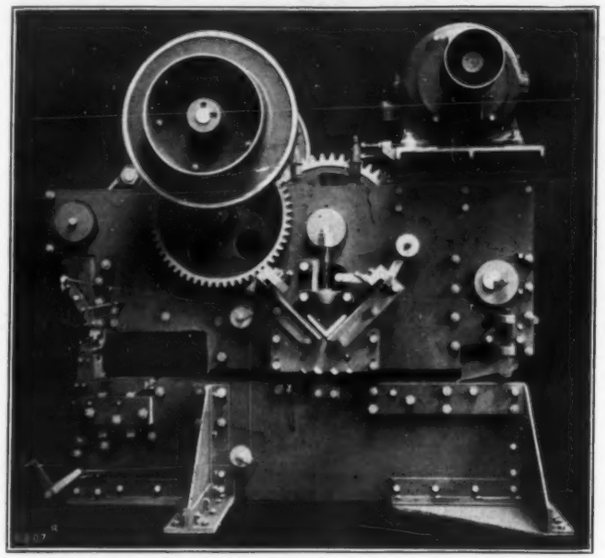
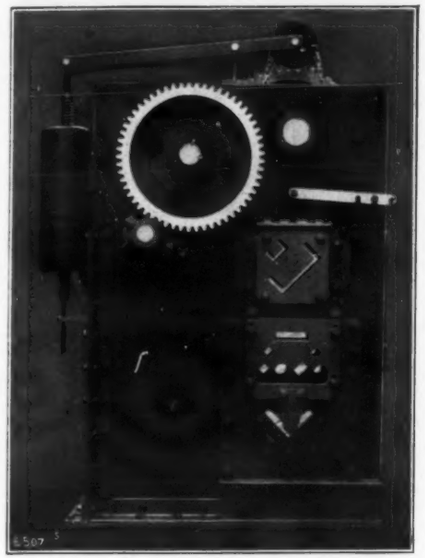
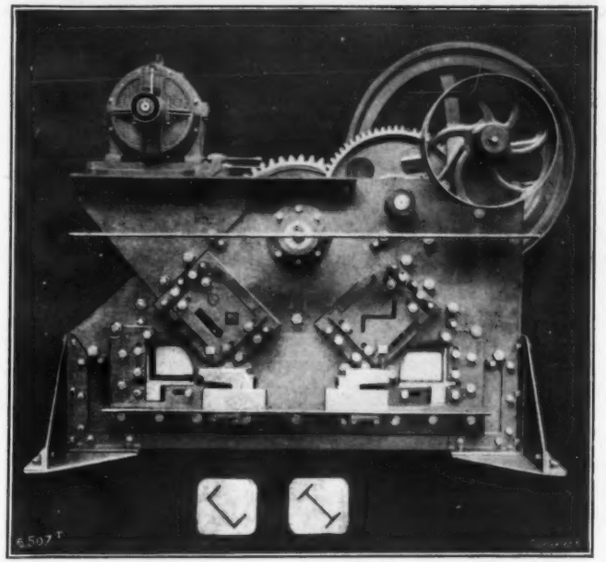


FIG. 159. PUNCHING, CROPPING AND SHEARING MACHINE; MESSRS. CRAIG AND DONALD, LTD.





FIGS. 160 AND 161. CROPPING MACHINES FOR BARS AND ROLLED SECTIONS; MESSRS. CRAIG AND DONALD, LTD.

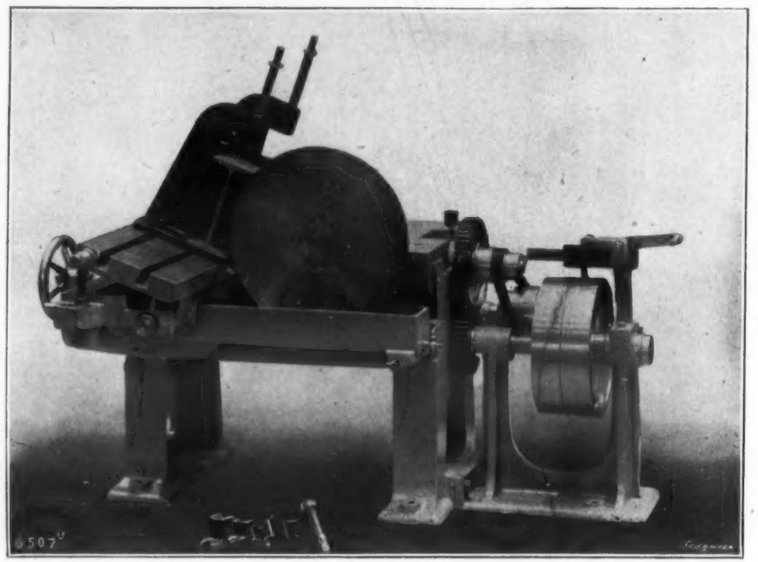


FIG. 162. COLD SAW FOR ROLLED SECTIONS; MESSRS. ISAAC HILL AND SON.

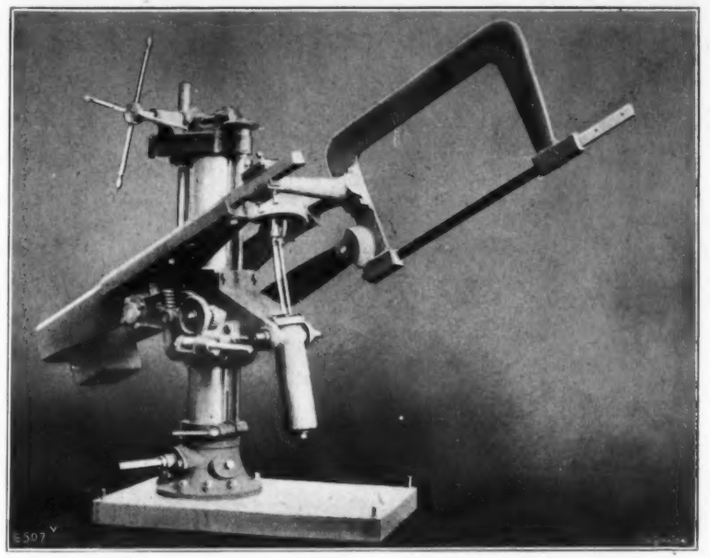


FIG. 163. RADIAL HACK SAW; MESSRS. E. G. HERBERT, LTD.

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The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick ,, ,,	£3	3	0
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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8596 GERRARD.

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With Eight One-Page Plates of the MACHINE TOOL AND ENGINEERING EXHIBITION AT OLYMPIA.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. New higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 377.

ENGINEERING.

FRIDAY, SEPTEMBER 17, 1920.

STRIKES.

THE general industrial situation at the present time can only be regarded by all with increasing concern and anxiety since the whole structure of industry at the moment of writing is threatened by the miners' strike, the lock out of members of electrical trades unions in the engineering industries, the shipyard platers and helpers' strike and many other minor labour disturbances taking or about to take place to the detriment of trade, to the hindrance of the reconstruction of industry, and with the direct effect of increasing the ever ascending costs of living. These unsettling movements are largely the result of two primary causes, the increasing cost of living with the growing experience that augmented wages do not necessarily mean an improvement in the standard of living possible, and dissatisfaction with the capitalist system of industrial organisation.

Whatever be the merits or demerits of the capitalist system, the majority of our level-headed working classes—and such form the larger portion of the community—do realise that it is quite useless to rail against any system, more especially against one that has in the past resulted in success and prosperity, until such time as a very sure alternative is available or at least until experiment is possible, without failure involving the probability—or at the present time, more accurately, the certainty—of a cataclysm.

The issue raised by the Penistone electricians' strike is by no means new. It has often been raised and recently with increasing frequency in different trades. The challenge to the management involved has previously been withdrawn after partial strikes concerning only a shop or a section of a works. That the matter could not be left to be settled locally by allowing the Penistone strike to take its natural course may not be generally appreciated. The tactics of labour in calling for a strike in one shop at a time, and supporting the small percentage of members so thrown idle from the earnings of the majority at work, has recently been generally successful. The individual firm, finding its trade going elsewhere is, after a relatively short time, constrained thus to concede the demand, often ending in a new wages level, to which other employers in the same industry under threat of similar strikes, must immediately increase their rates. The only effective reply possible to the policy of sectional strikes is the lock-out. To what extent a lock-out of electricians would affect the engineering and allied industries cannot yet be stated, but it would be considerable in view of the very important part played now by electrical appliances in every engineering establishment and in all engineering undertakings. The fact that the Electrical Trades Union has, however, now withdrawn the question of principle of the employment of a union foreman, opens the way to the settlement of this dispute.

Much more serious is the threatened miners' strike. If this materialises, it will deal a severe blow at all industry and will seriously cripple the trade of the country for a considerable time to come, certainly for much longer than the actual duration of the strike. For a recent example of the length of time required to overcome the ill effects of a stoppage in any industry, the English ironmoulders' strike of last year and its lasting effects will be remembered. The complete suspension of all activities in the coal-mining industry is, of course, most serious, and particularly so if the colliery enginemen and firemen refuse duty in sympathy with the miners proper. Efforts must be made in such an event to prevent the mines from becoming flooded. If the pumps were left unattended and flooding allowed to take place, it might be weeks or even months after the end of the strike before the normal output could be regained. Furthermore, it is probable in the case of certain mines that they would not be reopened at all at present, since the cost of redraining would be adjudged more than the possible gain. Although the strike notices have been handed in to expire on September 25, and the United Transport workers have agreed that the miners' claims are just and reasonable, and statements by the Transport Workers' leaders have been suggestive of moral support for the miners' actions, there is still plenty of time for a settlement to be reached provided there are grounds which can serve for a reopening of negotiations. As was expected, little in this direction has materialised from the Trades Union Congress last week at Portsmouth. It has been proposed that the basis on which the miners' weekly wages are calculated should be reviewed. The object in so doing would be to eradicate a number of the complications and anomalies operating at present. Like all other trades, where both time work and piece work are in vogue, there are a considerable number of anomalies, and if the basis of the miners' wage could be revised and simplified, so that the average worker could more readily understand the manner in which his pay was made up, nothing but gain could accrue. Furthermore, in such revision, piece work would no doubt be made more attractive and so increased output would be fostered. In connection with the work of the Trades Union Congress we may draw attention to Lord Weir's letter to *The Times* of yesterday, part of which we reproduce in another column.

Little objection to this course would be urged in any quarter, unless by those who oppose payment by results or any move whatsoever in that direction. The necessary negotiations to this end could quite readily be put in train—when and if the present miners' demands are modified—and do not require any elaborate machinery. The fact that the men's executive is to have a further interview with Sir Robert Horne is, we hope, an indication that more reasonable views are gaining influence. Hopes have been expressed in some quarters that on a basis of an increased wage for increased output a settlement of the present demand is possible. This suggestion requires to be examined critically, however equitable it may appear at first sight.

Making all allowances for the present state of the mines due largely to war conditions, the lack of shafts and the increased distances the coal has to be brought from the seams to the surface, the shortage of appliances facilitating output, the more difficult nature of the coal being hewn, the statement can be fully substantiated that the output of the miners is being seriously and wilfully restricted. The increased tonnage output for the week when the strike definitely threatened was exactly similar to the increased production always experienced with pieceworkers, and the better timekeeping of time-workers before holidays in anticipation of a temporary cessation of pay. This increased output, be it noted, was in spite of the published intention of the miners severely to restrict output before the cessation of work on the expiring of the strike notice, so that stocks should not be accumulated to negative in measure the compelling effects of the complete suspension of coal mining. Moreover, it has been proved in other industries that in spite of admittedly improved appliances the output per worker is considerably less per hour, and in one case as much as 20 per cent. less than it was before the war.

If then, the miners really require increased pay to

(To face page 371.)

maintain a required standard of life the remedy lies to their hand, either by increasing the intensity of work, by better timekeeping, or by a reversion to a longer working week. Statistics show that the average time worked is 4·9 shifts a week. Each shift is of seven hours. Estimates of government inspectors show that to each shift an average of 39 minutes has to be added for descending into and coming up from the mines. Therefore, the miner works on an average 37½ hours a week or just over 22 per cent. of the total week of seven days of 24 hours each. It is quite ridiculous to suggest that this will overtax the strength of any able-bodied man in even the very hardest task connected with mining, and for every really difficult job there will be several relatively easy ones, so that re-organisation whereby the length of day worked should be approximately proportional to the expenditures of physical energy called for should be quite readily accomplished, if desired.

Thus, if the miner desires more wages there is nothing to prevent him from earning them. If, on the other hand, the government were to agree to an increase of wages on a basis of increased output, unless the arranged scale were such that no increase at all were granted until such time as the present output was exceeded by, say, 10 to 15 per cent., meaning at the present rate of work only 41 to 43 hours per week (including in this the 39 minutes per shift already referred to)—then it would be an encouragement to others to follow the miners' example. Restriction of output would be encouraged in order to induce a bonus for an increase in speed of work to reach the normal. In this way another viscous circle would be started.

The other demand to which the miners have coined the application for an increase of wages as "one and indivisible"—the reduction in the price of household coal by 14*s.* 2*d.* per ton—has several objects in view. To attract public sympathy to the cause of the miners and to render the coal industry incapable of continuing on an economic basis without the reimposition of a large degree of state control and pooling, in the hope eventually of securing nationalisation, would appear to be the principal objects, though Mr. Smillie has recently stated that the miners are not out for nationalisation. This question has been settled by Parliament, who are properly the only body sufficiently representative to deal with such a matter affecting the whole community.

The public has not responded on this occasion, and without its support every strike is doomed to failure. This is a fundamental truth. Had the public wished a reduction in the price of domestic coal they would have demanded it. The short hours worked by the miners do not give much support of their claim for an increase of wages, especially when it can be shown that wages increases given to the miners since the Sankey award exceed the rise in the cost of living during this period. Moreover, as offered by Sir Robert Horne on Thursday, the 9th inst., this matter can well be referred to the Industrial Court, whose sole function is to review such questions. Nationalisation of any industry, even a key industry such as coal mining has been rejected by Parliament, and the community in general resent more deeply than the miners seem to realise, the threatening and brow-beating attitude assumed at the present time by the great trades union organisations.

Whilst the completely abortive results of the Portsmouth Congress and the meeting between Sir Robert Horne and the miners of Thursday, September 9 make the situation, at the moment of writing, such as to give rise to grave anxiety, yet it would have been too much to expect a solution, even partial, at such an early date. The meeting of yesterday appears to indicate that negotiations are possible again, and as the advance has been made from the men's side it may be hoped that some settlement may be arrived at before the 25th.

RIVER REGULATION IN AUSTRALIA.

WITH the several freaks of nature of which Australasia is the home, and which include such oddities as kiwis and kangaroos, the great Island continent of the group possesses what are probably the most capricious rivers in the world. Nominally the continent boasts of magnificent waterways. They are most impressive on the map, and as drawn the length of only two or three of them together run into thousands of miles. But the maps are deceptive. For a large part of the year some of these great waterways dwindle to less than nothing in the way of streams, becoming reduced to a mere series of disconnected puddles. This naturally has handicapped the development of anything like inland navigation on a large scale, to the great loss of the interior. Yet in spite of every possible obstacle there is a very fair amount of river traffic, but it is attended by risks. The climate is so inconstant that if a boat gets caught by the falling water it may be years before enough comes down again to float her.

Years ago a steamer pursued a giddy career up the Darling, and branching off up the Paroo, continued its way on beyond the Queensland border. To-day the Paroo is shown on the map as a double-ended river without a mouth and, as often as not, it has nothing at all to give to the Darling throughout the year. The Darling itself is always up and down. One year towns on it will be endangered by floods which will stretch as far as the eye can reach. It was said to have attained a width on one occasion of 43 miles. For years afterwards the same places may be threatened by drought. The navigation season at the most is short; only two months in the upper reaches, and the boat which has risked an extra trip, or has ventured a little over far up stream makes a veritable steeplechase of it with the falling water over bars and banks dividing the deeper stretches, in her anxiety not to get left. And when left, of course it is a question when the water comes again, whether it will float at all, with its open seams.

But the traffic has its attractions even now when the railways are slowly reaching further and further out. Before the days of the railways fortunes were made with boats sent on trading trips up river. South Australia as the lucky possessor of the seaport has naturally been anxious to foster this trade. On the other hand the two other States concerned have been the reverse of interested, since any project would probably benefit South Australia at the expense of their own railways. So the interior as a whole had to play second fiddle to these railways, and the stations in the back blocks were mulcted in heavy freight when a much cheaper form of traffic might have been developed on the rivers. Only in quite recent years has any breakaway from this crude policy been effected.

The rivers were first navigated by trading steamers in 1853. It took over sixty years to get the several States to act sufficiently in concert for any material advance to be made. Till that time practically the only river regulating work which had been attempted was that at Bourke on the Darling, a solitary weir and lock—said to be a very good lock, but it had one failing; the absence of water below it for most of the year made it of little service to navigation. It has, we believe, frequently had the honour of being used as a dry dock. Twenty-five years ago a committee evolved a scheme whereby the Darling could be locked for its whole length for less than one million and a quarter. The railway fetish killed it. Another scheme in 1899 suffered a like end. Whenever possible the up river states threw the responsibility for taking action on to the Federal authority, while South Australia made abortive endeavours all the while to get some agreement or other which would enable her to embark on a definite river policy. How attractive and valuable is this inland navigation is shown by the fact that on the first rumour of the water being up the stations will send their wool a hundred miles or so to catch a boat in preference to a very much shorter distance to the railway, and when the report has proved false, as sometimes it has, wool has waited at the port for two years before being put on board and taken down stream.

Generally speaking, the Murray is a more reliable stream than the Darling. It rises in snow mountains, and is not liable to the extremes of behaviour characteristic of the Darling fed by tropical torrents Yet even the Murray, usually navigable as far as Albury six months in the year, and which, in good years, may have been navigated for 1,100 miles from its mouth for the whole twelve months, has sometimes only been navigable for one month, while the flow has once, comparatively recently, practically ceased at Mildura not very far above its junction with the Darling, and the river been reduced to a series of pools. So the Murray has its lean years, though most still see a very fair amount of traffic on it.

Despairing of securing co-operation of any value from the other States in the matter of river regulation for navigation purposes, since New South Wales and Victoria, if interested in water conservation at all, were most concerned with irrigation and the feeding of their railways, South Australia, after an abortive conference in 1911, decided to commence its own works on the lower Murray reaches. Since then a pleasing change has come about, and work is in progress, or at least planned, under acts of 1915, involving a concerted scheme between the Commonwealth, and the States of New South Wales, Victoria and South Australia. The original estimate for this work was £4,663,000, of which the Commonwealth was to contribute one million sterling. The cost is now put at over seven millions, and it is probable that the authorities are now regretting the dilatoriness of former years. The projects on foot involve four large schemes, as follows:—The construction of 26 weirs and locks up the Murray as far as Echuca, 1,066 miles from its mouth, with storage works at Lake Victoria on the lower, and at Mitta Mitta on the upper, Murray; and the construction of nine weirs and locks on the Murrumbidgee, from its junction with the Murray up to Hay. Of these works, those as far up the Murray as Wentworth, about 400 miles from the mouth, are to be built by South Australia, though actually involving work in the two other States; those above on the Murray will be built jointly by New South Wales and Victoria, while those on the Murrumbidgee will be undertaken by New South Wales. The Darling is not included in the scheme, and it is said to be doubtful whether the cost of regulating that river would be warranted. No suitable storage sites have been found on it, and it would be difficult to utilise its water for irrigation.

The most forward of the works at the present time is the weir and lock at Blanchetown, South Australia. This was begun before the bigger scheme was put through, and had it not been for the war, and a series of unusual flood seasons, would have been finished ere now. It is the lowest work on the river. Three other locks and weirs are approved in South Australia and will be put in hand as early as possible. A similar work is already in hand at Torrumbarry, between Echuca and Swan Hill, and the work on the Mitta Mitta dam was officially inaugurated in November of last year.

The Blanchetown works have a total width across the river of about 600 ft. Of this 199 ft. are taken by a navigable pass, 344 ft. by sluices, and the remainder by a lock 56 ft. wide and 275 ft. long between gates. The navigable pass consists of a Boulé weir, the elements of which can, when so required, be completely removed from obstructing the waterway. The weir sections are supported by steel trestles placed about 20 ft. apart, hinged at the base, and, when not in use, capable of being laid flat down on the river bed. Stretching from top to top of these trestles on their up stream sides, is a 15 in. I beam. Resting against this at the top, and in shoes in the concrete at the base, is a series of inclined 18 in. I beams spaced about 3 ft. 4 in. apart. On the latter the iron-bound wooden panels are lowered, the bottom sections being each about 3 ft. high, the size gradually diminishing to 6½ in. strips at the top. The sluices have concrete piers, and openings 19 ft. wide, the stop logs being 12 in. by 12 in. and 10 in. by 10 in. jarrah. The whole of this work is carried on a concrete raft 6 ft. thick and 35 ft. wide with piling underneath. On the up stream side there is a steel sheet piling cut-off, and a clay blanket is carried out 50 ft. from the edge of the raft. On the down stream side protection is afforded by stone filled cribs. The lock provides a lift of 10 ft. Collision gates are not arranged.

Although not definitely settled, it is understood that the other works for which South Australia

is responsible, will be of a similar general character, modified of course to suit the various sites. The Torrumbarry weir which is in hand with departmental labour, consists of a weir and dam extending for about 480 ft. and a lock 56 ft. by 200 ft. In this case the weir is to be formed of wooden trestles each about 36 ft. long, resting on an inclined floor against a step in the concrete raft. The trestles can be completely removed from the waterway. Water will be impounded to a height of 16 ft. This work is being done in the dry in a cut-off which will form a straight reach where now there is a large bend.

The two most important works are the storage schemes. In the Lake Victoria scheme it is the intention to impound part of the flood water of the Murray in this natural depression in New South Wales, close to the South Australian border, and to release it as required in subsequent months. The area of the lake is 30,000 acres and a serviceable depth of water of 25 ft. is expected to be impounded giving between these two levels about 514,000 acre feet of stored water. The lake is naturally surrounded by high ground, and the work of making use of it is not a large undertaking. The embankment required for the channels, &c., will take about 1,200,000 cub. yards of material, and it is expected to be completed in about three years at a cost of £320,000, including regulators.

The Mitta Mitta dam will impound twice the quantity of water stored in Lake Victoria. The situation of this dam is a few miles east of Albury, at the junction of the Murray and Mitta Mitta Rivers. The lake formed will have an area of 47 square miles, and a catchment area of 6,000 square miles. The dam will be 2,700 ft. in length, and the spillway 740 ft. long, the outlet works taking an additional 161 ft. The dam is to have a 30 ft. roadway on its crest which will stand at 614 R.L. which is 85 ft. above the normal ground level at the site. The water level will be controlled so as not to rise above 602 R.L. The dam is to be of earth with a concrete core wall reaching down to hard granite. The earth slope up stream will be 3 to 1 pitched with heavy rock and grouted with concrete and mortar. The down stream face will be 2½ to 1 with the toe protected with rock. The spillway will consist of a concrete dam with upstream face vertical, and down stream face of 0·7 to 1. At the discharge works the concrete dam is, of course, suitably modified. There will be eight draw off pipes 6 ft. in diameter, and the intention is to combine a hydro-electric generating plant with the discharge. Over the spillway the roadway is carried on 30 concrete piers which also form the abutments for the regulating shutters. The latter has a clear opening of 20 ft. and a rise of 15 ft. There is no provision for boats to pass beyond the dam.

Most of the works in view will serve the dual purpose of improving navigation, and supplying irrigation colonies with water. The great Burrinjuck dam in the State of New South Wales is, of course, purely an irrigation scheme, but the new works at Torrumbarry, and some of those in South Australia will directly benefit areas capable of development by irrigation, and this will now probably be pushed ahead.

THE INSTITUTE OF METALS.

THE autumn meeting of the Institute of Metals took place at Barrow-in-Furness last Wednesday and yesterday.

On Wednesday morning the members, to the number of about 100, were welcomed at the Town Hall, by the Mayor of Barrow, Colonel W. F. A. Wadham, a director of the Barrow Hematite Steel Company, Limited, who, speaking both on behalf of the Corporation and of the inhabitants of the city, expressed the pleasure he felt at receiving the Institute on that occasion. When the visit to Barrow was first proposed, he, the Mayor, had a talk on the subject with Mr. H. B. Weeks as representing Sir James McKechnie, and the matter was finally decided on. The Institute was interested mainly in non-ferrous metallurgy, whilst the main interest of Barrow had always been in ferrous metallurgy, the latter having led to the rapid growth of the town. The origin of Barrow was to be traced to its natural resource in the share of iron ore, for utilising which metallurgical works were built, together with a railway and docks. He hoped the members would have favourable weather for their meetings, their visits to the works and also for their excursions to the surrounding country. Various institutions had already visited Barrow and on looking up the speeches made on these occasions by former mayors he had found that they took up some two columns in the journals. He proposed to inaugurate a change in that respect and to keep the members away from their business proceedings for a very short time only, but his welcome was none the less hearty for that. He hoped that one result of their visit would be to establish still closer connections between Barrow and their Institute.

Sir George Goodwin, the President, thanked the mayor for his cordial speech. The institutions in London paid periodical visits to the provinces to make themselves better known and to show the connection which their researches had with industry. The Institute dealt with non-ferrous metals, and in Barrow the works found great interest in both the non-ferrous and the ferrous. The way in which Barrow had grown was admirable. It had about 300 inhabitants in 1845, and now there were approximately 80,000. The town started with the ferrous industry and had developed to such a degree that now it had, besides, a most important shipbuilding industry also, which latter included the use of a large quantity of non-ferrous metals. Ships were now built in Barrow of practically any size up to the very largest, and there was manufactured there, besides, practically everything that was required in a warship. The Institute was glad to have come to Barrow; they had been received most cordially, and he felt sure the members would have an instructive and a pleasant visit.

The papers read and discussed at Wednesday's meeting were: "Notes on Brass Foundry Practice at Messrs. Vickers' Barrow Works," "Crystal Growth and Recrystallisation in Metals," "The Influence of Gases in High-Grade Brass," and "The Constitution of the Alloys of Aluminium and Magnesium." The first and third of these papers we publish in full this week, together with a portion of the second.

The members lunched on Wednesday at Messrs. Vickers' works, and yesterday at Furness Abbey Hotel, by invitation of the directors of the Barrow Hematite Steel Company.

Speaking at the lunch at Messrs. Vickers works on Wednesday, Sir James McKechnie said that on behalf of his colleagues in the Vickers' Company he had great pleasure in offering the Institute a hearty welcome to their works. He thought it appropriate that the Institute of Metals should visit such works, as the more those engaged in scientific research came in contact with factories where experimental research was applied commercially, the greater would be the concentration of effort towards finding a path that led to efficient production. The Iron and Steel Institute had brought the more common metals to a state when wonderful precision could be attained commercially; we were now in the position to specify compositions of thermal treatment to yield the exact quality desired for any engineering purpose. The Institute of Metals, in its short career had made even more remarkable progress in the discovery of the properties of metals other than iron and steel, and all alloys of metal. Strength could now be relied upon with great reduction in weight for productions of wide variety. Every engineer had abundant reason to be grateful to the Institute of Metals, and it was incumbent upon the engineers to give the Institute the fullest support in encouraging their work as an Institute, and the fullest support also to the individual members. The researches carried out by Dr. Bengough's Committee on Corrosion were classical for their all-embracing scope, for their careful execution, their thoroughness and the practical usefulness of the results. Individual members had done most beneficial service in private laboratories in connection with chemical and physical examinations of copper, brasses, bronzes, aluminium and its alloys, and all white metals. Sir James added that he did not want to be invidious in referring to special work of individual members, but thought he might be pardoned for mentioning Professor Carpenter's researches in connection with steel, gun metal, propeller material and the metallurgy of copper. He (Sir James) was glad also to see Professor Turner, and to remember his valuable contributions to the progress of non-ferrous metals. Dr. Rosenhain was a versatile and efficient investigator. As marine engineers, Sir James further stated, we were grateful also to Sir John Dewrance for his researches on the effect of temperature on the physical qualities of the copper, zinc and tin alloys. The volumes of the proceedings of the Institute were rich in results for the guidance of manufacturers, and he hoped that when the members went round the works in the afternoon they would find that Messrs. Vickers had utilised the Institute's researches to the fullest extent, and this, he thought, was the best indication of appreciation of the scientific work the members were doing.

There was a steady increase in the use of non-ferrous metals in ship-propelling machinery. In the old steam reciprocating engines only about 4 per cent. of the metal used was non-ferrous, but with double reduction geared turbines the percentage had increased to 7 or 8 per cent., whilst in cruisers it was 15 per cent. It would probably surprise the members to learn that in internal combustion engines for merchant ships there was only about 3 per cent. of non-ferrous metal, but in the largest and fastest submarine boats built at Barrow, where there was a combination of oil engines, steam turbines and electrical machinery, the proportion came out as high as 37 per cent. of non-ferrous to the total metal used. Probably this suggested that the marine engineer might find possibility for increasing power with minimum weights by resorting more to such metals, especially for naval machinery. In the Barrow works they had got tensile strengths up to 20 tons with large castings of Admiralty gun metal, with elongations up to 20 per cent. With high tensile brasses for propellers they had got over 40 tons, with elongations not less than those specified for the lower tensile metals.

Without non-ferrous metals it would have been impossible to produce the rigid airship. In the airship most recently constructed at Barrow, 86 per cent. of the metal used was duralumin, and of the remainder, 2 per cent. was aluminium castings and gun metal, 12 per cent. only was steel in the form of high-tensile wire. Duralumin, with a specific gravity of only 2·8, gave a tensile strength of 25 to 28 tons, with an elongation of 15 per cent.

Sir James, in concluding, gave the toast of the Institute of Metals, coupled with the name of his old friend and the Institute's distinguished president, Sir George Goodwin, a brilliant engineer, who had guided and stimulated their work along thoroughly practical lines.

Sir George Goodwin, in replying, said that the story of what Messrs. Vickers had done during the war had been told on many occasions. In Barrow they had carried out a great variety of work. They had built at Barrow during the war 64 warships, including four battleships of the highest class. The ships they had built included all types, battleships, cruisers, submarines, pinnaces, besides machinery in great variety, including turbine work in which the works had proved of great help. The first airship was built and was developed at Barrow, also the first submarine. Messrs. Vickers had built 53 submarines during the war, and their machinery had been copied in other yards. The works were now developing in merchant ship construction. During the war also the works lent a hand in the construction of mountings and in the manufacture of shells. The firm had organised a large works at Lancaster, also a filling factory at Morecambe. Sir James had been helped by a very efficient staff and he (Sir George Goodwin) could give a number of names in this connection, but would limit himself to the mention of that of Mr. H. B. Weeks, whose work afforded an illustration of the manner in which scientific researches could be utilised in every day practice.

Sir James returned his thanks on behalf of his colleagues and staff and on his own behalf.

Visits to works and to places of interest in the vicinity took place on both days. We shall report upon the discussion of the papers in our next issue.

CEMENT MANUFACTURE IN CHINA.—The *Canton Times* reports that Chinese merchants contemplate establishing five cement factories to compete with foreigners.

NOTES.

PATENT APPLICATIONS.

IT has been observed by a number of people that the applications for Letters Patent filed in this country during the present year are far in excess of those for any other year. Apparently, however, it is not generally known what is the reason for this advance, and incorrect conclusions may be drawn from it. In the ordinary way, applications are lodged throughout the year with surprising regularity, and as a general rule there is a small increase in the total number of applications lodged from one year to another. The filing of applications proceeded regularly and at a rate somewhat above that of 1919 up to the end of June in this year. After that an enormous increase occurred and continued until the middle of July. From that time applications were regularly filed at the rate corresponding substantially to that at the beginning of the year. The reason for the sudden change was due to the Peace Treaty with Germany. Article 308 of that Treaty provides that the rights of priority . . . which had not expired on August 1, 1914, and those which have arisen during the war . . . shall be extended . . . for the period of six months after the coming into force of the present Treaty. This Treaty was ratified on January 10, 1920, so that patent applications had to be lodged by foreigners proceeding under the treaty by July 10, 1920. Although the increase in applications during the year was in part due to such foreign inventors advantage was taken by them of the Treaty provisions to a very great extent at the last moment. English manufacturers should, therefore, bear this fact in mind because all these patent applications lodged by foreigners are potential blocking patents which will prevent use, or at least full and uncontrolled use, of the matters patented. The growth of patent applications ordinarily corresponds to an increase in trade and at first sight it may be thought that the large advance in the number of applications referred to above is due to energy on the part of British manufacturers. The explanation just given, however, will throw new light on the matter. For purposes of comparison the following approximate figures are given for applications lodged by the end of the months June, July and August respectively, for the last few years :—

	June.	July.	August.
1913	15,000	17,500	19,500
1914	15,600	18,000	19,100
1915	9,500	10,800	12,300
1916	9,600	11,000	12,500
1917	10,000	11,500	12,700
1918	10,700	12,500	14,100
1919	16,500	19,000	21,300
1920	18,000	22,800	25,000

If applications are lodged at the present rate for the remainder of the year the very high number of 39,000 will be reached.

DEEP MINING ON THE RAND.

In his presidential address to the South African Institution of Engineers, Mr. J. Whitehouse states that observations made at the Village Deep Mine show that the rock temperature at a depth of 5,487 ft. is 89·4 deg. The rate of rise in this case was 1deg. F. for every 253·9 ft. increase in depth, which is notably less than has been observed elsewhere. The air temperature at this depth is 72·6 deg. F. by the dry bulb thermometer and 71·6 deg. by the wet bulb, which is considered satisfactory considering the distance travelled by the air. In the case of the St. John Del Rey mine, where the depth is 6,126 ft., the rock temperature was 114·4 deg. F. and the air temperature, as measured by the dry bulb thermometer, was 109 deg. Mr. Whitehouse recalls Dr. Haldane's investigations in which it was found that with a wet bulb temperature of 88 deg. F. in still air, the body temperature would rise even during rest. In a good current of air, however, a wet bulb temperature of several degrees higher could be borne, and continuous moderate work was, in fact, possible with a wet bulb temperature of 85 deg. F. A good air current is therefore, Mr. Whitehouse considers, essential to the efficiency of miners working at great depths and has moreover the advantage of removing the dust. This dust is responsible for the miners' phthisis which now burdens the gold mining industry of the Transvaal to the extent of 1,200,000*l.* per annum. As mines have deepened costs have gone up. In 1914 the cost of timbering and rockwalling averaged 10*d.* per ton crushed, and on the same basis the cost in 1919 would have been 1*s.* 9·6*d.* per ton. Actually the figure was 2*s.* 5·4*d.*, the difference being due to the rise in wages and in the cost of materials. Winding cost 1*s.* 8·6*d.* per ton in 1914 were 2*s.* 9·7*d.* in 1919. Of this increase 8·5*d.* was directly due to the increase in the depth from which the ore was raised. Including other factors, the total increase in the cost per ton crushed has been 2*s.* 5½*d.* per ton on the basis of 1914 prices, and to this has to be added the increase due to higher wages and higher material costs.

THE BRITISH ASSOCIATION.

(*Continued from page* 356.)

WE now conclude our account of the proceedings of Section A.

THE BUILDING UP OF ATOMS.

In his discourse on the building-up of atoms Sir Ernest Rutherford confined himself to the structure of the nucleus, disregarding the outer electrons. His communication carried the matter further than his Royal Institution lecture of last year* and his Bakerian lecture delivered before the Royal Society last June. The nucleus, he stated, had only 1/100,000 of the dimensions of the atom probably; its positive charge determined the number of outer electrons and gave directly the atomic number of an element. When α particles of the swiftest type were discharged against a heavy element like gold, the α particles brushed the outer electrons aside and penetrated almost up to the positively-charged nucleus; there, however, the α were repelled and scattered, a few being actually turned back, and from their behaviour we knew that the law of inverse squares held good close up to the nucleus, *i.e.*, within 3×10^{-13} cm. The α particle was itself a fragment of radium, probably a brick (not necessarily a fundamental one) in building up atoms, and the nucleus again might be complex, its charge being the resultant of its positive and negative charges. As both uranium and thorium disintegrated down into lead, we did not know how far the rule evolved for heavy atoms applied to the lighter. But the light atoms seemed actually to be broken down by the bombardment with α particles, though there need not be mechanical impact.

When hydrogen molecules were bombarded by α particles, there was very little scattering, the law of inverse squares failed, and an unknown law came in. The hydrogen atoms were driven away in front of the α particles, as described in the Bakerian lecture, travelling four times further nearly in the same direction; we thus seemed actually to have penetrated into the nucleus. The helium nucleus survived and hence should be very stable. When nitrogen was similarly bombarded, some (very few) particles were formed which behaved like hydrogen; the tests explained relied on deflections; chemical tests could not be made. These particles were not due to water vapour, and the bombardment of oxygen or carbon-dioxide did not give hydrogen atoms, but other peculiar particles. Thus, hydrogen of mass 1, seemed to be a dissociation product of nitrogen, whilst from oxygen and carbon dioxide particles of masses 3 and 2, not of mass 1, were ejected. The particle 3 might be an isotope of helium (mass 4) unknown in the laboratory. Similar studies had been made with solids, nitrides and fluorides of boron, titanium, &c.; but solids might contain water or ordinary hydrogen; they were full of holes (even mica), whilst gases had no holes; hence the research was restricted to gases.

What, then, was the constitution of the elements and their nuclei? The views he proceeded to put forward were tentative and highly speculative, but not in discord with theory. Helium seemed to be the only element expelled in radioactive disintegration which never expelled hydrogen H nor H_2. But hydrogen (the H nucleus) and electrons seemed to be the ultimate constituents of other nuclei generally. Sir Ernest represented the two constituents in his models by red (positive) and white (negative) balls. A pair of red and white balls, in very close juxtaposition, would give the unknown doublet neutron of mass 1 and charge 0, the hydrogen atom having mass 1 and charge 1. Two red balls with one white between them would give mass 2 and charge 1. Three red balls arranged in a plane about a central white one and spinning about an axis through the centre, at right angles to the plane (all the models were assumed to spin), would have mass 3 and charge 2. If the balls were very close to one another their resultant mass would be smaller than the sum of the masses owing to the interaction between the electromagnetic masses. Thus helium (4 red plus 2 white balls) had the mass 3·997, which was less than 4 H = 4·032; Sommerfeld had calculated that such a helium atom should be very stable, as it proved experimentally. Taking, further, H_2 as a constituent brick, lithium might be built up so as to have masses 6 or 7, both with charges 3; beryllium might have the masses 9, 10, 11 and the charges 4, 5, 5; carbon mass 12, charge 6; nitrogen mass 14, charge 7. The models also indicated why it would be easier to expel H from nitrogen than from oxygen, in which hydrogen would be protected by surrounding masses 3, which might themselves be expelled. In other models helium, mass 4, itself formed the brick.

Professor Eddington, opening the discussion, remarked that the Rutherford atom had been designated by his name; it was now so generally accepted that the name had been dropped. Sir Oliver Lodge could not see how the positive charges rotated about the others, and he suggested a new name for the positive hydrogen nucleus to avoid confusion with the ordinary atom; Sir Ernest had spoken of atoms. Professor Horton asked why none of the hypothetical compounds—unless very unstable—had been formed though bombardments had gone on for ages. Professor Fowler thought that H_3 should spectroscopically be distinguishable from helium by a displacement of 0·2 Angström unit. Sir Ernest, replying, said that he would be surprised to find his H_3—as well as the neutron—though it might be fairly stable and might occur in stellar nebulæ. A clear nomenclature was certainly wanted; the term "prouton" for "proton" might be suitable for the H nucleus, and a new nomenclature might also change the name of helium and radium into helion and radion in analogy to neon, argon, &c.

THE ORIGIN OF SPECTRA.

The discussion on the origin of spectra was very instructive, but it hardly admits of abstracting. In opening the discussion Professor A. Fowler, F.R.S., said he would give a brief account of the observations which theory had to explain. Different series of lines could be sorted out of the multitude of lines by their different electrical, magnetic and other properties, and formulæ had been found for the various series by Balmer, Paschen, Ritz, Rydberg, Hicks, and others. The wave-length λ of the principal series was given by $\lambda = 3646{\cdot}16\ m^2/(m^2-4)$, where m was any integer above 2. It was preferable to express the formulæ in terms of wave-numbers ν (the number of waves per cm.), and then $\nu = 27418{\cdot}75 - N/m^2$, where N was Rydberg's constant, common to all the elements and equal 109678·3 (Hicks' latest value). Four chief series were now distinguished, the principal P, the diffuse D, and sharp S series (the lines being respectively diffused or sharp), and the fundamental (Bergmann) series F. Combination series, 2 P–3 S, &c., were also recognised. The lines might be single (then marked P, D, S, F) or doublets or triplets (marked p, d . . .); all the series were interrelated, S more to P, F more to D. The separation in doublets was constant in the D and S, but decreasing as we approached the limit in the ultraviolet, where all the lines become crowded, in the P and F series. For the same group of elements the separation between the components of a doublet was proportional to the square of the atomic weight and hence increased; for example, in the order Mg, Ca, Ba, Sr. The satellites (a distinctive term adopted for convenience) further

* See ENGINEERING, vol. cvii, page 793.

complicated the spectra; in the series of Ca, the triplet was well defined; in the D series the chief member of the triplet was slightly shifted, the satellite occupying the normal position. In the enhanced lines of spark spectra some new lines appeared intensified whilst others dropped out; to account for these Bohr had replaced N by $N_1 = 2^2N$, and we might have to go further and introduce $N_2 = 3^2N$, the multiples of N being connected with the multiple charges of the particles. A new elegant way of plotting, not the spectrum lines, but their sequence, on a logarithmic scale of wave-numbers had been introduced by R. T. Birge. The scale of wave numbers increased from left to right; the nucleus would be at the extreme right of the diagram, and the vertical bars (to avoid the term lines) drawn represented the orbits (elliptical or rings) of the electrons about the nucleus and at the same time the respective sharp or principal lines, &c., of the spectrum $1 \cdot 5\ s$, $2\ p_1$, $3\ s$, &c. When the volts applied were able to hurl the electron from $1 \cdot 5\ s$ to $2\ p_1$, the wave number of the radiation emitted by the electron falling back would be $1 \cdot 5\ s - 2\ p_1$.

Concluding, Professor Fowler remarked that many spectra did not show any regularity so far; none of the formulæ were absolutely accurate except those for the Balmer series of hydrogen and the enhanced (Fowler) series of helium. But the chief thing to explain was why the wave number always came out as a difference of two terms, one of which was the limit of the series (which generally appeared as a term of another series), and the other a function of N. To the uninitiated the whole seems hopelessly complex, though the ground is really being cleared up, and it is regrettable that there is no accord as to the symbols; n or ν may stand for wave-number or for frequency.

Professor J. W. Nicholson, F.R.S., dealing with the theory, said that the chief difficulty even with a theory like Bohr's was the lack of definiteness of the dimensions of the atom as regards the radii of the electron orbits. Bohr, moreover, could not explain the endless numbers of lines of Hicks and others, and the observations agreed with ν where theory agreed with ν^2. But Bohr's atom had accounted for many peculiarities in the spectra of hydrogen and helium, and his ideas had been modified and generalised by Sommerfeld for non-circular orbits, thus explaining the fine-line spectra. Professor Nicholson proceeded to show how Bohr had applied the quantum relation to the spectra ("quantised the energy")*, and how he had explained the discrepancy, arising from the fact that a nucleus carrying several charges, in equilibrium with all its electrons, would not be in equilibrium when one of them was expelled, the whole then forming a system rotating about a common centre. Paschen had shown that the satellites became more complex with increasing atomic weight, which could be explained, provided the sum of three terms in the energy equation remained constant. Epstein had accounted for the Stark effect on the quantum theory, and Stark himself had verified some of Epstein's further conclusions. But we did not understand why certain components fluctuated in intensity, and so far the mathematical difficulties of quantising the spectrum were too great.

Professor W. L. Bragg,† of Leeds, considered the hypothesis (of Kossel and Lewis) of regarding the electrons as grouped in stationary positions more acceptable to chemists, and as fruitful as Bohr's suggestion, and he briefly indicated the bearing of this hypothesis on spectroscopy. Mr. C. G. Darwin, Cambridge, said that he believed in Bohr and in the quantum theory; but both were very difficult, in spite of Sommerfeld. Frequency was very fundamental apparently, but also extraordinarily derivative. We had no idea as to the minimum train of waves which would give rise to a radiation. Professor Nicholson had said that any system of co-ordinates, *e.g.*, parabolic, might be used; but then the orbits became different, whilst the energy calculations gave the same lines. The Zeeman effect had been explained by Lorentz before the days of the quantum theory. Professor J. C. McLennan, Toronto, reminded the Section of his work on single line spectra (also mentioned in Sir J. J. Thomson's lectures); further study, particularly of the absorption, was needed. Dr. A. E. Oxley, Manchester, referred to the magnetic properties of hydrogen and helium. The hydrogen atom should be paramagnetic, and Sir Robert Hadfield had found that manganese fused in a hydrogen atmosphere was paramagnetic. But the hydrogen molecule, which on Bohr's theory might be represented as consisting of two nuclei with two electrons rotating in a vertical plane between the two, should also be paramagnetic, whilst Kamerlingh Onnes found liquid hydrogen diamagnetic. It was similar with helium. Bohr's model could not be accepted, whilst Bragg's theory accounted for the magnetic properties and also for the ν instead of ν^2. Professor Nicholson replied to this objection that the orbit of the hydrogen electrons need not be circular; the electrons might oscillate up and down in a line or describe contracted paths; Bohr had modified his model.

* We would refer our readers as to this and as to series in spectra to Sir J. J. Thomson's lectures on "Spectrum Analysis and Atomic Structure," ENGINEERING, vol. cvii.

† Compare Professor Bragg's recent lecture on "Arrangement of Atoms in Crystals," ENGINEERING, vol. cix, page 701.

MAGNETISM AND THE STRUCTURE OF THE ATOM.

The paper of this title, read by Dr. A. E. Oxley, of Manchester, dealt with the deportment of crystals in magnetic fields as bearing upon the structure of the atom. It had been observed by Tyndall and others, he stated, that a diamagnetic crystal, suspended between the poles of a magnet, would place itself in such a position that its main plane of cleavage was equatorial to the horizontal polar axis, whilst paramagnetic bodies assumed an axial position. This tendency was decisive and overcame the natural inclination of the suspended crystal to hang with its longest dimension in the vertical. In order to test this tendency, Dr. Oxley experimented with thin plates of naphthalene which placed themselves equatorially. Building up a cube of these small plates and finally a prismatic body, twice as long as high, he observed that the orientation in the field remained unchanged, *i.e.*, the plates (like the leaves of a book) were still at right angles to the polar axis, although the chief dimension was first vertical and finally horizontal. These facts, as well as the already mentioned diamagnetism of hydrogen and all the rare gases, helium, &c., was incompatible with Bohr's view of electrons rotating in large circles about their nucleus. In the case of hydrogen Dr. Oxley assumed that each electron described a small circle in the plane of the base of a cone (of acute angle), the apex of which was the nucleus. In the two atoms of the molecule the two cones were turned towards one another, and the sense of the rotation was such that the two electrons attracted one another; the two electrons of the molecule thus coupled the atom into a stable molecule. With more complicated systems the pairs of small circular orbits were similarly disposed by magnetic forces; in solid crystals the electrons likewise described small orbits about their normal positions, and were not free to rotate in large circles, nor stationary as they would be according to Lewis and Langmuir.

THE IONISATION OF ATMOSPHERIC NEON.

Last year* Professor F. Horton and Miss A. C. Davies, of the Royal Holloway College, contributed two papers on the ionisation and luminosity of helium and argon. This year they had a similar paper on "The Ionisation of Atmospheric Neon," stating that they had found two critical electron velocities for the production of radiation, viz., 11·8 and 17·8 volts, and three other critical velocities, viz., 16·7, 20·0, 22·8 volts, for the production of ionisation. The velocities of 11·8 volts and 16·7 volts, and the velocities of 17·8 volts and 22·8 volts seemed to be associated; the radiation velocity corresponding to the ionisation velocity of 20·0 volts had possibly been overlooked. None of these velocities could be attributed to the displacement of a second neon-electron, and neon was so far the only gas known which showed more than one critical velocity for the removal of a first electron from the atom. The study of the spectra showed that the lines of the principal series appeared first at 20·0 volts, the lines of the subordinate series never being visible below 22 8 volts. The phenomena might be interpreted to indicate that there were several isotopes of neon, having the same critical electronic velocities. In that case, however, one would expect the complete spectrum of the element of lower ionising velocity to burst out first. That was not so, and Professor Horton concluded hence that the different critical velocities corresponded to the displacements of external electrons, differently, *i.e.*, asymetrically, arranged about the nucleus.

* See ENGINEERING, vol. cviii, page 468.

LIQUID-PLANE PARALLEL PLATE INTERFEROMETER.

For the study of interferences of very high order and the resolution of very close spectrum lines Lummer introduced twenty years ago the plane-parallel plate of glass. A beam of light entering the glass at one end of the plate at grazing incidence, is reflected within the glass in zig-zag at the lower and upper surfaces; at each upper point some light escapes, and the many pencils of rays emerging from the upper surface interfere with one another. Instead of a glass plate Mr. H. P. Waran, of Madras College, now in the Cavendish Laboratory, has tried a liquid film of water or oil floating on mercury. In his account of his researches he mentioned that his first laboratory equipment was very poor; he had to make his own mercury vapour lamps, &c., and he could not get the mercury trough, on which a layer of water was floating, sufficiently steady to prevent tremors. The vertical light beam fell on a silvered mirror mounted obliquely in the water; later the beam was made to fall on a prism fixed in the one end of the trough. When the trough was steady, he obtained two parallel bands of fringes, the one displaced with respect to the other, due, apparently to the circumstance that the reflections from the upper surface (air-water) and the lower (water-mercury) did not take place under the same conditions. He hence placed a Lummer glass slab on the mercury, and he then distinctly observed two clear systems of fringes, displaced as indicated. When he polarised the incident light, the one or the other system vanished, according to the plane of polarisation, because each system belonged to one of the components of the elliptically-polarised light, resulting from the metallic reflection. Mr. Waran dealt in his paper further with the study of the phase differences between these two components, and he showed that these phase differences and the optical constants of his liquid and solid (mercury or silver on glass) film can be determined experimentally. He had meanwhile improved his apparatus in Madras by placing the trough, suspended by copper wires, from the ceiling, within a water tank, itself supported by a special pillar in the basement of the college building. Work has to be done in the quiet hours of the night. Castor oil was found preferable to water as liquid; glycerin did not answer owing to its hygroscopic character.

THICKNESS OF STRATIFIED FILMS.

The paper on the Thickness of Stratified Films, communicated by Dr. P. V. Wells, of the Washington Bureau of Standards, forms a continuation of recent researches by Marcelin and by Perrin on liquid and soap films. According to Perrin, stratified films are formed by the superposition of elementary films, the total thickness being a multiple of the thickness of the elementary film, estimated at 5 millimicroms $\mu\mu$. Dr. Wells supplied the quantitative measurements. Like Perrin he uses a photometric method, comparing the brightness of the light reflected by the film in question with that of a white film, which is the brightest of all the films (black, grey, coloured), and his apparatus comprises mirrors and also prisms for reflection and a biprism and nicols for bringing two fields of equal colour into juxtaposition. By these means he facilitates the intensity comparison of the films or spots of monochromatic light of higher orders, which differ very little in brightness. The measurements were made on films of aqueous solutions of potassium oleate in various concentrations, of glycerin and of uranin. Films of these solutions appear in the first instance white, but in intense agitation; they develop coloured spots and fringes, bordered in the irregular fashion of the level contours of maps;

then a few black spots of thinnest and most stable film appear and spread, leaving the other liquid in the shape of droplets and also in fibrous channels in which a lively circulation continues. The thickness of the black spot found by Wells for oleate and for glycerin is about 4×10^{-7} cm.; with Perrin he regards the film as bimolecular, each layer of pure oleic acid having a thickness of about $1 \cdot 9 \times 10^{-7}$ cm. (Perrin), whilst Langmuir considers the thinnest films (oil films on water) as monomolecular and of thickness $2 \cdot 3 \times 10^{-7}$ cm. The oleates will spread on a water surface because they contain the active CO . OH group which is soluble in water, and is characterised by a double bond, whilst the insoluble pure hydrocarbons do not spread. The research was conducted in Paris under Perrin.

Vapour Pressure.

In his paper on "Vapour Pressure," Captain J. H. Shaxby considered the work done against the cohesive forces of an "ideal" liquid and its vapour, and showed that the space "occupied" by molecules (in the sense of the kinetic theory) was equal to the space "free" from molecules in the saturated vapour at the same temperature, and *vice versa*. The expression for the vapour pressure deduced from this relation and from Dieterici's equation involved the gas constant, the absolute temperature and the densities of liquid and vapour. A second equation was deduced for the isothermals of a vapour. These equations were found to hold with fair accuracy, except at temperatures well above the critical; with certain modifications they represented the experimental facts with great accuracy at all temperatures.

The Ultra-Micrometer.

The Ultra-micrometer of Professor R. Whiddington, Leeds, is a thermoionic valve instrument for measuring extremely minute distances of the order of atomic diameters. The principle, he explained, was that a very slight change in the distance between the plates of the condenser in circuit with the valve made a very great change in the frequency of the oscillations, and if the valve were arranged for heterodyne beat receiving, the instrument became exceedingly delicate. For the standardisation of the condenser the plates were mounted on vertical steel bars sliding in guides; when one of the bars was laterally loaded (by a weight over a pulley), a weight of a few milligrammes, bending the bar imperceptibly, was sufficient to make the telephone speak, it being joined to the valve by an amplifier. We would refer our readers to Professor Whiddington's paper on self-oscillations in valves of last year.* He did not explain how the instrument is actually coupled with the quantity to be measured. Sir Oliver Lodge, commenting upon the paper, remarked that the method measured a very slight change in the originally small distance between the condenser plates. Sir Ernest Rutherford, Mr. F. E. Smith and Dr. P. E. Shaw dwelt upon the extreme sensitiveness of these valves to any disturbance, the near approach of the hand being sufficient to alter the capacity of the system; Professor Whiddington admitted that he had to shield his apparatus, to put it in tin-lined boxes and to work at night.

Determination of Gravity at Sea.

On behalf of the Committee on the Determination of Gravity at Sea, Professor W. G. Duffield, D.Sc., of University College, Reading, reported that certain problems were being investigated in preparation for a further voyage. A preliminary report on the effect of the ship's vibrations on the height of a mercury column is appended to the report. Apparatus of the type previously used by George Darwin, in which a column of mercury was balanced against a constant volume of air maintained at a constant temperature, had been designed in such a manner, that it could almost entirely be made of steel, and the apparatus was under construction. The efficacy of a steel contact point, to indicate the constancy of volume of a mass of mercury contained in tubes of various diameters, was under further examination.

Mathematical Papers.

We can only mention the mathematical papers submitted by Major F. A. MacMahon, F.R.S., on a "New Binomial Theorem and its Arithmetic Interpretation"; by Professor G. H. Bryan, F.R.S., on "Triangles"; by Professor H. Hilton, F.R.S., on "Plane Algebraic Curves of Degree n with a Multiple Point of Order $n-1$ and a Conic of $2n$-Point Contact"; and by Mr. T. C. Lewis, of Cambridge, "Is there in Space of Three Dimensions an Analogue to Feuerbach's Theorem? Is there anything corresponding to the Hart System?"

(To be continued.)

* See Engineering, October 10, 1919, page 470.

LITERATURE.

Modern Road Construction: A Practical Treatise for the Use of Engineers, Students, Members of Local Authorities, &c. By Francis Wood, M.Inst.C.E., F.G.S., Borough Surveyor of Blackpool. Second edition, enlarged. London: Griffin and Co., Limited. [Price 21*s.*]

The first edition of this work appeared before the war, when the necessity for the extension and improvement of the means of transport was becoming evident, but before the authorities appreciated the magnitude of the change that was approaching, or the amount and character of the traffic for which it would be necessary to make provision. From the author's then position of borough engineer at Fulham, he could gauge the growing urgency of the demand, that aims at securing door to door transport of passengers and goods, with the view of eventually placing the country resident in the favoured position of the townsman. To meet the new demand, road surfaces will have to be constructed of such a character that the running costs of the vehicles that use them will be reduced to a minimum, while the expense of construction and maintenance need to be made as low as possible. In general terms, this is the problem which the author attacks, and is one whose solution can be supplied only by experiment. Hence the necessity for examining the question periodically, and marking the progress every few years, a necessity that the author has recognised by issuing this new edition. He has no doubt rewritten and enlarged his earlier work, but the trammels of the original are apparent, and the old arrangement has fettered his freedom.

Macadam roads are now generally condemned as unsatisfactory for modern traffic. They were constructed to meet conditions that are passing away, and met public requirements for many years. Macadam's principle was sound, and the use of his materials judicious, but he was not called upon to provide for the advent of rapidly moving heavy vehicles, and consequently no adequate protection was provided against the excessive wear to which roads are now subjected. Moreover, his plan of construction has not been rigidly followed, and some of the evils that have followed arise from the neglect of his methods. He claimed that the rough angular broken granite should be allowed to knit and weld itself together into a compact mass, under the action of the traffic, using as little water or binding material as possible. The demand for a quickly-made road, with a comparatively smooth surface, has led to the free use of the heavy roller, while the hose pipe plays over a surface of loamy material or binding agent spread broadcast over the surface to promote consolidation. One consequence of this treatment is, that in dry weather the road is intolerable from dust, and in wet weather impassable from mud. The term "water-bound" road is far preferable to macadam, for in modern constructed roads of this character, it is only when moderate moisture has been precipitated, that a fairly good surface can be maintained. The author's remarks on the effect of weather on road surfaces are very good, and may be taken as evidence that this variable is receiving adequate consideration. Further proof is afforded by the prominence given to this matter in the resolutions adopted by the International Road Congress, where it is asserted "that weather conditions are amongst the most powerful influences which cause deterioration of roads, and that the destructive effects of weather can be minimised by effective waterproofing of the road surface, together with suitable drainage for the foundation."

The assertion is made from observations founded on experience, that a good class macadam road, properly constructed, with good foundation, and under ordinary heavy traffic, will not last more than two years, but that if the road were laid with concrete foundation and 2-in. layer of rock asphalt, or similar material, it would, with the same amount of traffic, retain a comparatively even surface for probably twenty years. Few such roads can have had twenty years' continuous use, from which reliable statistics can be deduced, and one of the difficulties in deciding on the merits of forms of road construction is the length of time during which experiments and examination must be continued, in order to derive trustworthy data. Information is rapidly accumulating, but the variables are many and intricate. These depend both on the road and the vehicle. Among the latter factors must be reckoned, the action of the wheel rolling, the diameter of the wheel and the width of the tyre; the distribution of weight on the axles and the amount of vibration, all of which are matters of prime importance, as railway management long since discovered, and their operation on a soft and resilient road surface is of greater moment than similar effects on smooth steel rails. The type of vehicle running on the roads as well as the means of propulsion are gradually changing, and this transition still further complicates the problem, since for many years to come the surface will have to be suited to both horse-drawn and mechanically-propelled vehicles. The author considers all these variables very fully, he has collected much of the information that has been published, tested it by his own experience and presents the general position very efficiently.

No final and decisive conclusion can be drawn, for as the author very properly reminds us it is unwise to assume that because a form of road construction has been very successful in one place or district, that without further adaptation or amendment, that same form will prove equally successful in a totally different district under dissimilar conditions. But enough is known to show, that in the future, no road will be satisfactory in use, or economical in construction, that does not permit the surface to be waterproofed by some preparation such as coal tar or bitumen. Abundant evidence has been collected by various authorities, demonstrating the effect of wear on differently conditioned roads during the war. Lack of labour and of road material on the one hand, and excessive traffic on the other, have worked sad havoc, but more in proportion on the water-bound roads. The doleful outlook which may have been unconsciously exaggerated in some cases, does not apply to those that have been rendered impervious to the weather by the use of a binder. A good example is furnished by the main road from London to Folkestone, for the motor traffic has been exceedingly heavy, and though few repairs have been effected its surface is as well adapted for motor wagons as before the war. Heavy rainfalls instead of injuring the roadway have efficiently scavengered it, and proved that such roads are self-cleaning. The waterbound roads are generally in a bad way and with all the attention the new Road Board can give the subject, the grant in aid of new construction and repairs will probably prove lamentably inadequate.

The author examines various kinds of construction that have been recommended and are in use, pointing out differences in detail that affect the traffic, and comes to the conclusion that the road structure which gave the greatest satisfaction on economic and mechanical grounds is a two coat bituminous paving. Having regard to its first cost, its life and capacity, for resisting ordinary forms of traffic, this paving takes a high place among competitors. Its cleanliness and low charges for maintenance also give it a pre-eminence over other kinds, at least in London suburban traffic of a fairly heavy character. The original cost of other forms of structure is less, but this advantage is only apparent, if more frequent and more costly repairs are needed to preserve a smooth and efficient surface. In favour of this pavement it may be further urged that various materials of local origin, as clinker, broken sandstone and limestone, or granite removed from reconstructed roads, can be used in the aggregate, the bitumen is the only ingredient that need be imported. Very precise instructions are given for

the preparation of the materials and the method of laying as also of costs, but this latter item, based on pre-war prices, is of little service now.

The structural merit claimed for this pavement is that every solid particle is firmly embedded in the bitumen which, even in low temperatures, possesses sufficient viscosity and ductability to transfer the pressure to the adjoining particles, while no stone materially alters its position. Waterbound roads wear out by reason of the material being ground away by friction due to the traffic causing the stones to rub against each other. Consequently, instead of remaining angular, they gradually assume a spherical shape resembling wave-moved shingle.

The more even surface obtained by the use of concrete, asphalt and other materials on road construction has exposed a new source of trouble, due to the formation of systematically arranged corrugations in the cover. These waves, slight at first, under increased traffic grow more pronounced, and eventually the road has to be broken up and relaid. Repairs of concrete and asphalt roads, it may be said in passing, are more expensive to effect, and occasion more annoyance to the public, than is the case with macadam. Road engineers are by no means agreed in the explanation they offer for these sinuous undulations due to traffic. Some attribute the defect to the method of rolling the surface in the process of finishing. Mr. Wood, however, very pertinently remarks, that these corrugations make their appearance on wooden pavements that are not rolled at all. The effect was less noticeable with horse than with motor traffic, and this accentuation of the evil by greater weight has led some to trace the effect to the pulsations of the engine that propel the vehicle, or to connect the corrugations with the speed, or the stresses in the vehicle itself. The author assigns the general creeping effect to the different temperatures prevailing at the surface, and beneath the surface, of the bitumen. The filler dust in the bitumen prevents it from flowing, but owing to the traffic forces, a thin layer of bitumen is pushed out of its original position, while the lower layers remain stationary, giving rise to a slight ridge. The action of the springs on the vehicle may aggravate this effect and however slight the depressions or the rise may be, a motion in the springs would be occasioned. It is difficult to accept the view that a harder bitumen would provide a remedy, for this wave formation can be detected on the steel rails of railway and tramway lines.

The study of this peculiar effect of wheels rolling over surfaces of varying degrees of rigidity and elasticity offers some interesting problems, whose solution may be of great practical use in suggesting an effectual remedy. A method has indeed been devised by Mr. Drummond, of Paisley, which it is claimed has reduced the annoyance to a minimum. Unfortunately the author has not discussed the method, or given any indication of its success, which apparently depends upon the degree of firmness with which the stones can be embedded in a stratum of pitch or bitumen. It is probable that some light will be thrown on this, as on other unsettled questions by observing the behaviour of the various road stones, tars, and bituminous binders that are being tested under actual conditions of heavy traffic at Sidcup. Mr. Wood, in conjunction with Mr. H. T. Chapman, the county surveyor of Kent, gives, in an appendix, some very interesting particulars of the present condition of the several trial lengths of roadway, laid down under the supervision of the Advisory Engineering Committee of the Road Board, with the view of instituting a reliable test of the effects of ordinary wheeled traffic on selected materials and combinations. The number of specimens is 23, covering a superficial area of 18,420 sq. yards, with a lineal length of carriageway of 2,490 yards, and carrying in August, 1912, about 3,500 tons per day. The coloured sheet prepared to exhibit the original cost, and the expense of repairing is very instructive. In drawing conclusions as to total expenses, it must be remembered that these costs are founded on the amounts paid to contractors for small lengths laid under expensive conditions, and do not indicate the cost of laying the various materials in large quantities under average commercial relations. The absolute cost is, however, of far less consequence than the relative, since the present revolution in prices of material and labour has upset all estimates. It is easy to perceive at a glance the relative cost of the various sections, and approximately the amount and frequency of necessary repairs. Where the original cost of construction appears unusually high, as with Durex and Roadamant, it is possible to find attenuating circumstances and, when analysed, there is no great difference in the cost of preparing and laying the several specimens, more especially as the length of life is still undetermined. As much may be learned from failures as from successes, and the author pleads, as we think, justifiably, that some sections that have worn less satisfactorily than others should not be condemned till the reason of the failure has been discovered and analysed. For instance, several sections that have been experimentally treated with bituminous carpets have worn badly in the five years they have been under examination, but it would be unjust and unwise to condemn the carpet system on the evidence collected. The author as at present advised divides the prize between a 3½-in. Durax armouring, and a Trinidad asphalt-macadam base, with a 1-in. Trinidad asphalt carpet. Single pitch grouting receives a commendation. Slag tar macadam gives good results; the two-coat being preferable to the one-coat pavement. It is to be hoped that the information to be drawn from this elaborate experiment will not come too late to guide engineers in the determination of a plan for resurfacing the vast mileage of roads with which the Road Board is confronted. The extension and improvement of our roads is of quite equal importance with the extension and maintenance of our railways, though the obvious truth may not be readily admitted.

BOOKS RECEIVED.

Internal Combustion Engines. Their Principles and Application to Automobile, Aircraft and Marine Purposes. By WALLACE L. LIND. London: Ginn and Co. [Price 10s. net.]

Nos Maitres les Oiseaux. Étude sur le Vol animal et la Récupération de l'Energie dans les Fluides. Par ETIENNE CHIMICHEN. Paris: Dunod. [Price 15 Francs net.]

Report on the Progress and Condition of the United States National Museum for the Year ending June 30, 1919. Washington: Government Printing Office.

Utilisation des Vapeurs D'Echappement dans les Houillères en vue de la Production D'Energie Electrique. Par ADRIEN BARJOU. Paris: Gauthier-Villars et Cie.

Liquid Air and the Liquefaction of Gases. By T. O'CONNOR SLOANE, Ph.D. Third edition, revised and enlarged. London: Constable and Co., Limited. [Price 21s. net.]

Principles and Practice of Aerial Navigation. By Lieutenant J. E. DUMBLETON. London: Crosby, Lockwood and Son. [Price 12s. 6d. net.]

Aircrews in Theory and Experiment. By A. FAGE, A.R.C.Sc., D.I.C. London: Constable and Co., Limited. [Price 34s. net.]

The Life and Work of Sir Hiram S. Maxim. By P. FLEURY MOTTELAY. London: John Lane. [Price 7s. 6d. net.]

Detail Design of Marine Screw Propellers. By DOUGLAS H. JACKSON, M.I.Mar.E. London: Sir Isaac Pitman and Sons, Limited. [Price 6s. net.]

A Text-Book of Electrical Engineering. Translated from the German of Dr. ADOLF THOMÄLEN. By GEORGE W. O. HOWE, D.Sc., Wh.Sc., M.I.E.E. Fifth edition. London: Edward Arnold. [Price 28s. net.]

The Application to Industry of Direction Control and Light. By F. M. LAWSON. London: Sir Isaac Pitman and Sons, Limited. [Price 8s. 6d. net.]

Irrigation Pocket Book, or Facts, Figures and Formulæ for Irrigation Engineers. By ROBERT BURTON BUCKLEY, C.S.I. Third edition. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 30s. net.]

Experimental Researches and Reports. Vol. II, 1918–19. Published by the Department of Glass Technology, The University, Sheffield.

Technical Writing. By T. A. RICKARD. First edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 7s. 6d. net.]

CONFERENCE ON INDUSTRIAL WELFARE.—A lecture conference for welfare supervisors will be held at Balliol College, Oxford, from the 17th to the 20th inst. The conference will begin this evening, when a lecture on "The Economic Background" will be delivered by Mr. Henry Clay, Fellow of New College. To-morrow three lectures will be given in the morning, afternoon and evening respectively on "Education and Welfare," "Industrial Psychology" and "The Human Factor in Industry," by various authorities. The course will be continued on Sunday when two further lectures will be given. The secretary of the conference is Mr. C. Cullen, Stair 2, Room 1, Balliol College, while the address of the Industrial Welfare Society, under whose auspices the conference is being held, is 51, Palace-street, Westminster, S.W. 1.

CRYSTAL GROWTH AND RECRYSTALLISATION IN METALS.*

By Professor H. C. H. CARPENTER, M.A., Ph.D., A.R.S.M., F.R.S., Past-President (London), and Miss C. F. ELAM, Member (London).

THREE years ago one of the authors published a research in collaboration with Mr. L. Tavernor, in the Journal of the Institute, entitled "The Effects of Heat at Various Temperatures on the Rate of Softening of Cold Rolled Aluminium Sheet." The research has been continued since that date with special reference to the changes in the mechanical properties which occur between 200 deg. C. and the ordinary temperature. In this temperature range they are very much slower than those which take place above 200 deg. C., and after this lapse of time are even now not yet completed. In due course it is hoped to publish an account of them. Arising out of this investigation, and closely connected with it, the present authors, rather more than two years ago, took up the study of the structural changes which occur during the softening of the metal. In the course of this a number of observations were made which it was very difficult to explain in the light of any existing hypotheses or theories. Accordingly, it was found necessary to study the whole subject in a broader way, and this has been done.

The facts which this study has revealed are set forth in the following paper, and they relate, as its title indicates, to two aspects of the changes which heat produces on worked metals, viz., (1) Crystal growth, (2) recrystallisation. Viewing the results as a whole, it is the authors' opinion that they are not capable of being explained by any of the theories which have yet been put forward, and the object of the present paper is to set forth the evidence obtained and the conclusions founded upon it, and to submit them to the judgment of the scientific world. The authors are not, as yet, themselves prepared to advance any hypothesis which undertakes to explain all the phenomena observed. It is considered that even though this is so, publication should no longer be delayed. If the evidence and conclusions stand the test of scientific criticism, existing hypotheses and theories of crystal growth and recrystallisation will have to be examined anew, and the facts which have been brought to light in the following investigation must find their explanation and their place, either in a modified form of one of the existing theories, or in a new theory altogether. Before dealing with recrystallisation and crystal growth, it is necessary to have a clear conception as to what is really meant by these two terms. In most cases these words, which signify quite different phenomena, have been previously used quite indiscriminately, and interchangeably, with the result that the discussion of this subject has necessarily been confused and unsatisfactory.

By "*recrystallisation*" the authors mean the complete re-orientation of a crystal or a group of crystals. The new arrangement starts from new centres, and is quite independent of the old system of orientation. It is, in fact, the birth of new differently-oriented crystals in a crystal aggregate and the gradual change of the old to conform with the new. This always gives a refined structure. When all trace of the old arrangement has disappeared, it is considered that recrystallisation is complete.

By "*crystal growth*" they mean the rearrangement of certain crystals in a crystal aggregate to conform with the orientation of certain other crystals, during which process the latter increase in size by the addition of re-oriented material at the same time as the former decrease in size by the same amount. This process necessarily leads to an increase in crystal size.

Changes in crystal size which include both recrystallisation and crystal growth may take place under three conditions: (1) On heating a metal after it has been plastically deformed; (2) On heating or cooling a metal through a phase change; (3) On heating electrically deposited metals. Neither (2) nor (3) has come within the scope of the present research, which has been confined almost entirely to the effects of heat following work. The mechanical effects of plastic deformation need not be referred to here. Heat tends to restore to such a plastically deformed metal the properties it possessed before it was subjected to work, and to replace the distorted crystals by new equiaxed crystals.

After referring in detail to the researches made by other scientists, the authors remark that the following research has been carried out mainly with: (1) Cold-rolled aluminium sheets of more than one degree of purity; (2) an alloy of tin and antimony containing about 1·5 per cent. of the latter metal. The aluminium sheet was ¼ in. thick and had been rolled from the casting, whose dimensions were approximately 21 in. by 9 in. by 4½ in., without any intermediate annealing. The purest material contained 99·6 per cent. aluminium, the chief impurities being iron 0·17 per cent. and silicon 0·22 per cent. Ordinary commercial aluminium was also used containing 98·9 per cent. of this metal. The alloy of tin and antimony was in the form of a casting. In the cast state this alloy is duplex in structure and very much cored. Prolonged annealing enables the antimony to pass into solution, and thus produces a single phase alloy. This is much accelerated by work.

Both these materials are difficult to polish and etch, and the authors give a description of the method of preparation of the specimens.

The antimony-tin alloy possesses a very peculiar property, which made it of great value for studying crystal growth and recrystallisation. If a polished and etched specimen be heated at 150 deg. C. to 200 deg. C.

* Abstract of a paper read before the Institute of Metals, at Barrow-in-Furness, on September 15.

and growth of any of the crystals takes place, the position of the new boundary is marked by a line which is really a difference of level, almost as if the specimen had been etched, but there was no visible change in the surface of the re-oriented area. That these lines represent the position of the new boundaries after heating could be shown by (i) taking a photograph of an area which included some of them, and (ii) repolishing and re-etching the specimen and re-photographing the same area. On comparing the two photographs, the boundaries of the crystals, as shown by etching in (ii), corresponded exactly with the new lines in (i). This can be made clearer by referring to Figs. 1, 2, and 3, which illustrate the entire absorption of a small crystal by four large ones. Fig. 1 shows the area before heating; Fig. 2 shows the same area after heating. It will be seen that the small crystal is now intersected by four lines. Fig. 3 shows the same area repolished and re-etched. The small crystal has entirely vanished, whereas the four large crystals have all increased in size by their share of the small crystal. The four lines intersecting the small crystal in Fig. 2 are in reality the new boundaries of the four large crystals. The share of the small crystal which each has taken in shown in Fig. 2 by the areas enclosed between the old and new boundaries. This is one of the simplest cases observed, but is quite sufficient to establish the identity of the markings which appear on this alloy on heating. Fig. 4 is also a very simple case showing the growth of a small crystal which has been heated once. It also shows the beautiful etch obtained with hot tartaric acid. It was always a simple matter to distinguish between a growing crystal and one that was being absorbed. This alloy tarnishes on heating, turning first yellow, then orange, red, purple, blue and green. Just as the crystals etch differently so they tarnish differently, but they tarnish first in accordance with the original etch. There is always a colour contrast between adjacent crystals, and the colour fixes the original boundaries. If new boundaries appear *inside* this colour boundary, it shows that the adjacent crystal is growing into it; if *outside*, then it follows that the crystal is growing into its neighbour. These colour contrasts, which are very noticeable in the actual specimens, are unfortunately impossible to reproduce in an ordinary photograph. The tarnish is only formed when the specimen has been etched with ammonium sulphide, whether it is heated in air or *in vacuo*. The boundary markings, however, are found on heating, whatever the reagent used and whether the specimen is heated in air, hydrogen, or *in vacuo*. Most of the specimens were etched in ammonium sulphide for the reason already given, and also because the extraordinary contrast between some of the crystals made it much easier to fix the area under supervision. This proved to be no easy matter when an area changed very much on heating.

A very remarkable feature about these boundary markings is that they are only formed when the specimen is removed from the oven and cooled. If a specimen be heated and cooled four times, there will be four new boundaries round some of the crystals; if five times, there will be five, and so on. But if another specimen were heated along with the first and taken out after the fifth time, only one boundary marking was visible and no intermediate stages were seen. It is therefore an arrest in the progress of growth that makes these markings on the surface, and further heating does not obliterate them. There is no sign of them, however, after polishing and etching, only the final and genuine crystal boundary being then visible.

Two photographs, Figs. 5 and 6, illustrate the curious effect produced on the surface by repeated heatings and coolings. Fig. 5 shows a five-sided crystal invaded on four sides for five heats. In the last and sixth heat, all five crystals have grown in and left nothing of the original crystal. This is illustrated more clearly in Diagram 1. Only the original and final boundaries are shown, the former by means of dotted lines. If the specimen had been repolished and re-etched at this stage these would not have been visible. Fig. 6 is more complicated, and shows the invasion of two moderately sized crystals and two small ones. Diagram (No. 2) of this has been prepared to facilitate the interpretation. Here, again, the original boundaries are shown by means of dotted lines. The four crystals that disappear are A, B, C, and D. The crystals that grow are E., F., G., H., I., and J.

much more rapidly, and the five boundaries are seen to be comparatively far apart.

It will be evident that this alloy provided exceptional opportunities for studying crystal growth. A large number of samples were examined, and a few typical examples of the growth exhibited will now be described. The method of procedure was as follows: A specimen was cut from the casting and either annealed directly or polished first of all. As has already been said, a prolonged annealing was necessary to remove the cores, but this was much hastened by work. Cutting alone produced recrystallisation and consequent disappearance of the cores, but a still quicker method of obtaining a good specimen for experiment is to squeeze the alloy against a smooth surface, such as plate glass. Wet polishing is all that is then required to give a good surface. Recrystallisation is also rapid, followed by crystal growth, which could be studied in the manner already described. It was generally found desirable to heat the specimen for some time after working to enable

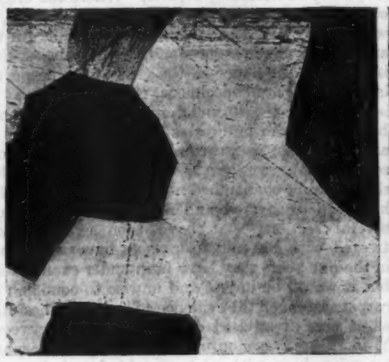


FIG. 1.

FIG. 2.

FIG. 3.

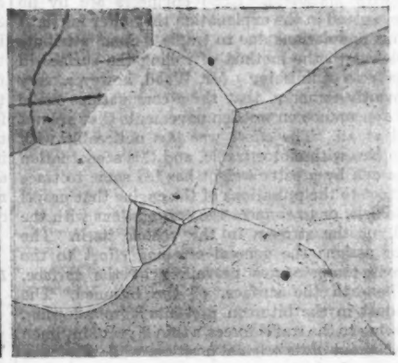


FIG. 4.

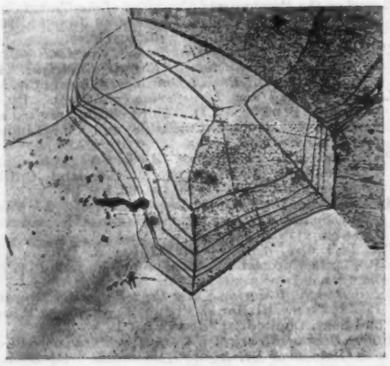


FIG. 5.

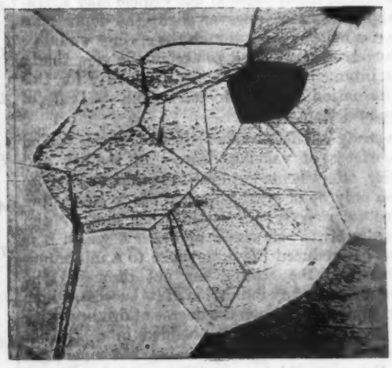
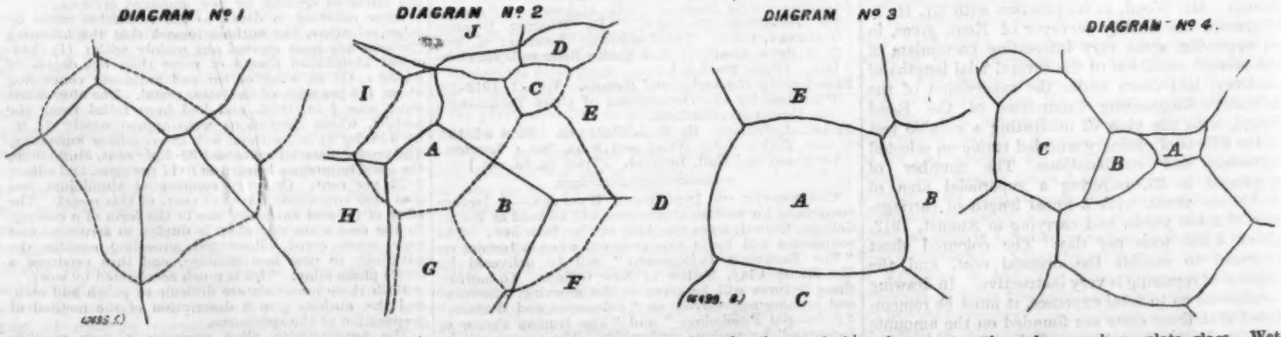


FIG. 6.

Magnification 100 diams. Reduced by one-sixth.



This photograph shows that sometimes the new boundaries are very close together, as between G and H, indicating that growth of G into H was very slow. All five boundaries were distinguishable in the actual specimen, though they do not appear so in the photograph. At the same time G grew into both A and B

CRYSTAL GROWTH AND RECRYSTALLISATION IN METALS.

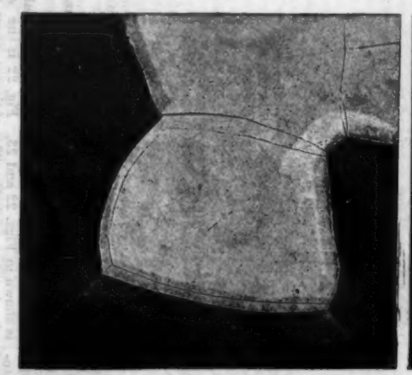


FIG. 7. 1st Heat.

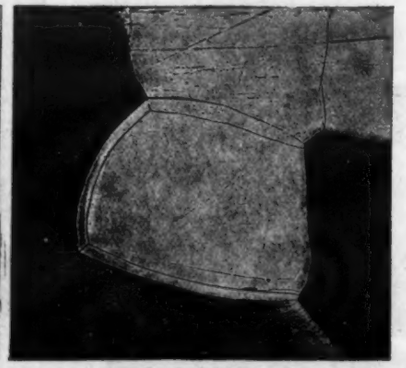


FIG. 8. 2nd Heat.

FIG. 9. 3rd Heat.

FIG. 10. 4th Heat.

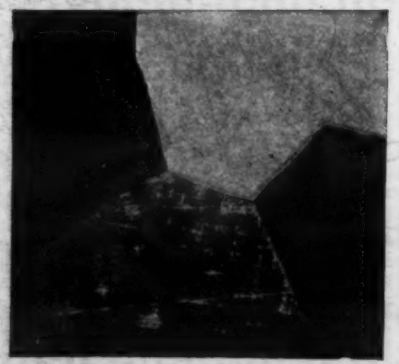


FIG. 11. Same as Fig. 10, repolished and re-etched.

NOTE.

Microphotographs, Figs. 7 to 11, illustrating the growth of crystals. This series should be studied with Diagram 3.

Microphotographs, Figs. 12 to 17, illustrating the disappearance of three crystals. These should be studied with Diagram 4.

The reproductions are from photographs in which the specimen was magnified 100 diams. These have been reduced one-sixth in the engravings.

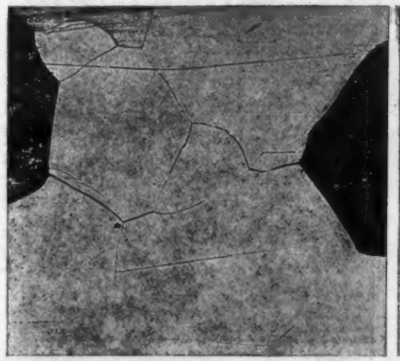


FIG. 12. 1st Heat.

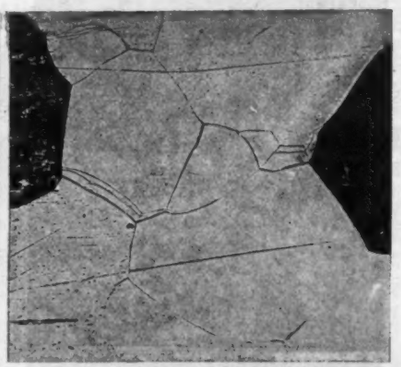


FIG. 13. 2nd Heat.

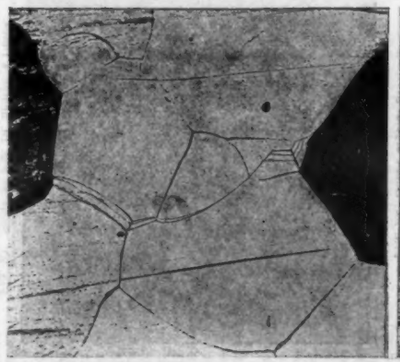


FIG. 14. 3rd Heat.

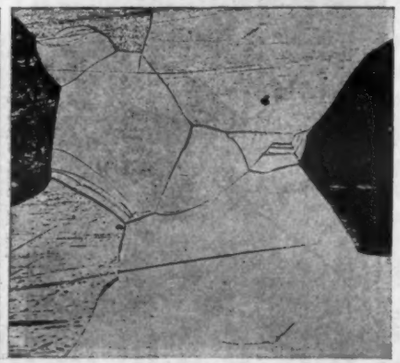


FIG. 15. 4th Heat.

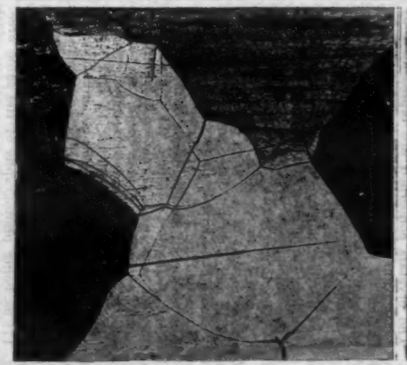


FIG. 16. 5th Heat.

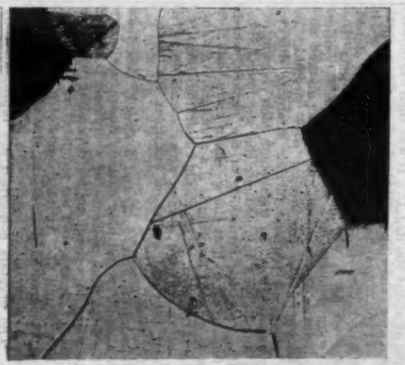


FIG. 17. Same as Fig. 16, repolished and re-etched.

the crystals to attain a considerable size. When a specimen was prepared as above, it was carefully polished and etched and heated in a small gas oven for 30 minutes at about 200 deg. C. It was then examined, and certain areas showing new boundary markings were marked and photographed. The specimen was then either reheated directly, or repolished and re-etched first. As soon as it was well established that the markings were genuine and represented the position of the boundaries at that stage, the former method was usually adopted. The advantages were twofold. In the first place, all possible further straining due to polishing was avoided. In the second, each stage up to the final anneal was retained on the specimen. The disadvantage was the tarnishing of the surface, which made it impossible to heat the specimen more than five or six times without repolishing if a photograph of any part of it was required. This was not a serious difficulty, however, as there were always areas which changed rapidly and provided sufficient examples for photographic purposes.

The photographs Figs. 1, 2, and 3 already described show how a small crystal may entirely disappear in one heat. The total disappearance of a crystal, however, may take place in several stages depending upon its size, the rate of growth, and the temperature of annealing (see Figs. 5 and 6). Another series of photographs illustrating the gradual decrease in size and final disappearance of a crystal in four stages is shown in Figs. 7 to 11. The crystals concerned are represented by letters in the Diagram (No. 3), and will be referred to by them. Fig. 7 shows the effect of heating once. The crystal A has been invaded by crystals C D, and E. Crystal C continues to grow on further heating, and also crystal B to a small extent (Figs. 8 and 9). The state of things after heating four times is shown in Fig. 10. All four crystals have invaded A, and C and E have met. Fig. 11 is of the same area repolished and re-etched, and shows that A no longer exists. The orientations of crystals, B, C, and D, as revealed by the etching are very different from that of A. It is possible that the orientations of A and E do not differ greatly. Yet each crystal has taken a considerable share of A. The same result was shown in Figs. 1, 2, and 3, where the small crystal was shared by all its neighbours, although each was of different orientation. In fact, the evidence from a large number of observations has shown definitely that neither similarity of orientation nor the reverse affects the absorption of one crystal by others during growth.

Another series of photographs (Figs. 12 to 17) illustrates changes occurring over a larger area, involving the disappearance of three crystals, A, B, and C, in the Diagram (No. 4). In this case unless the steps in the change had actually been seen and photographed, it would be difficult to recognise the first (Fig. 12) and the last (Fig. 17) as being photographs of the same area. This series requires only a brief commentary. Each succeeding photograph represents a further change in the absorption of the crystals A, B, and C. One feature is worthy of special notice. It will be seen that no invasion of crystal C took place during the third heat, but it recommenced in the fourth. Such an occurrence was by no means uncommon. The periods of annealing were usually 30 minutes, but it was frequently found that a change did not always take place on every heat, and occasionally growth would stop for one whole period and yet begin again on further heating. It was also observed that the last stage in the disappearance of a crystal, or crystals, took place very rapidly. This is illustrated by most of the photographs. There seemed to be no relation between the time during which the specimen was heated and the amount of change that took place, i.e., the rate of growth was far from constant.

Most of the examples hitherto given have been of large crystals invading small ones. This was by no means what always occurred, and the reverse was often seen to take place, especially in the earlier stages of growth following recrystallisation. There is always the possibility that an apparently small crystal is in reality a part of a large crystal, and it may be contended that the cases of growth of small crystals observed are not genuine. Such an argument, however, can be applied equally well to the examples just described in which an apparently small crystal is invaded by large ones. It is sufficient to say that growth was not confined entirely to the larger grains.

A photograph (Fig. 4) has already been shown of a small crystal growing after being heated once. Fig. 18, shows a small crystal, whose original size is shown by the darkened area in the centre, which has grown to the limit of the outer boundary marking. That it has grown, and that the true boundary is the outer marking, is shown in Fig. 19, which is of the same area as Fig. 18, but taken after the specimen had been repolished and re-etched. On further heating, new lines were formed outside the boundary of Fig. 19. After heating four times another photograph was taken (Fig. 20), and the specimen was repolished and etched, and the new boundary as seen in Fig. 21 corresponds to the outermost marking of Fig. 20. It will be noticed that the smaller crystal in the top right-hand corner of the first two photographs has been absorbed. This same crystal continued growing on further heating, but it had reached the limits of what might be described as a small crystal in Fig. 21, so no further photographs were taken.

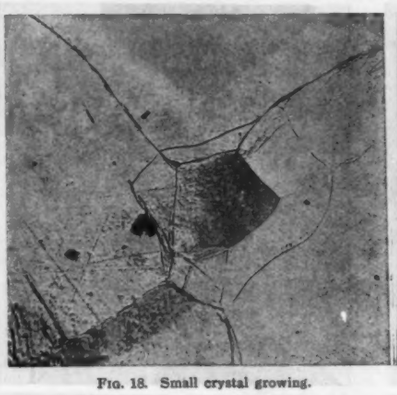


FIG. 18. Small crystal growing.

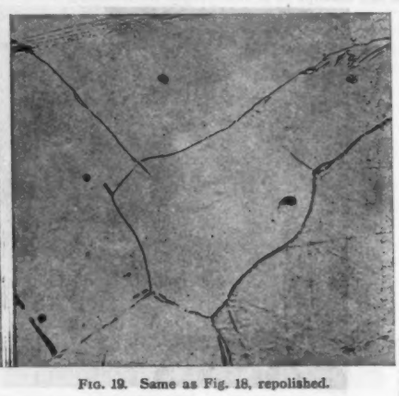


FIG. 19. Same as Fig. 18, repolished.

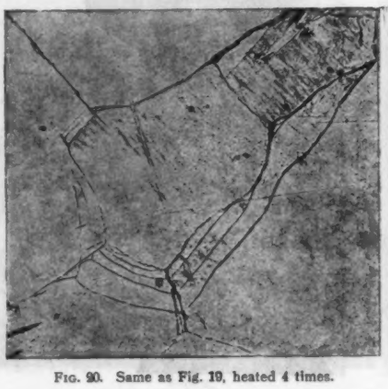


FIG. 20. Same as Fig. 19, heated 4 times.

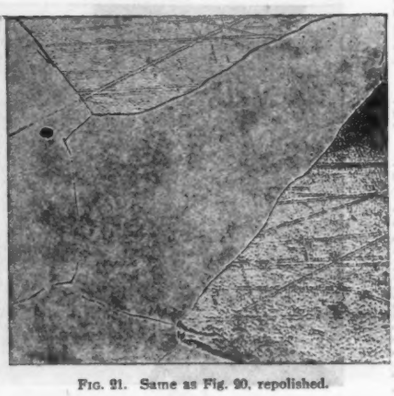


FIG. 21. Same as Fig. 20, repolished.

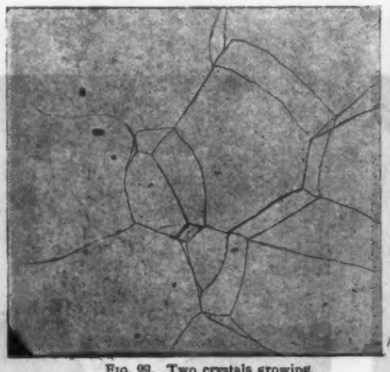


FIG. 22. Two crystals growing.

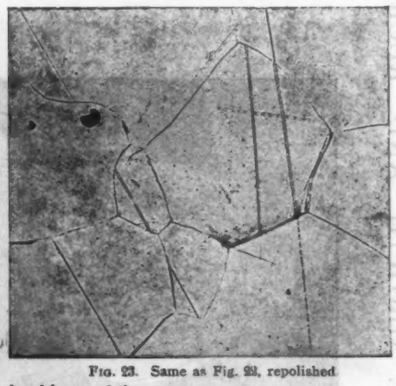


FIG. 23. Same as Fig. 22, repolished.

Magnification 75 diams. Reduced by one-sixth.

DIAGRAM No 5.

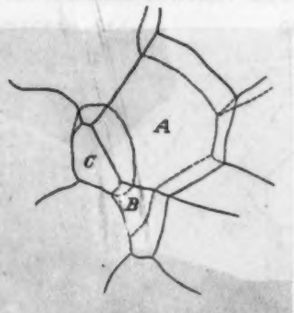
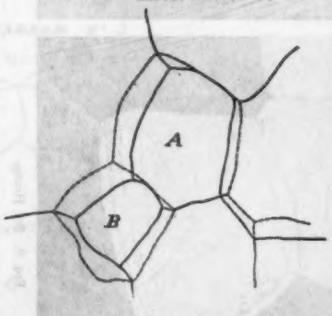


DIAGRAM No 6.



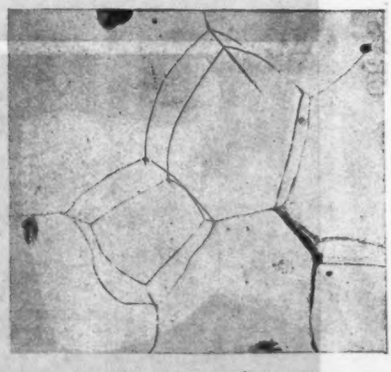


FIG. 24. Crystal growing and grown into. × 75.

An interesting example of two small crystals growing is shown in Figs. 22 and 23. Fig. 22 is the appearance after heating, while Fig. 23 is of the same area repolished.

Reference to Diagram 5 will make clear what happened. The two growing crystals are A and B. This photograph shows both the growth and the absorption of a small crystal in the same field. It has also been observed that a crystal may grow and be invaded at the same time. This is illustrated in Fig. 24, and also Diagram No. 6. Crystals A and B are being invaded by their neighbours. At the same time, however, A has grown into B in two places. This was by no means an uncommon occurrence.

(To be continued.)

NOTES ON BRASS FOUNDRY PRACTICE AT MESSRS. VICKERS, LTD., BARROW-IN-FURNESS.*

By H. B. WEEKS, F.I.C., Member of Council, Barrow-in-Furness.

A RETROSPECT of the progress of almost any long-established undertaking cannot fail to reveal, to an astonishing degree, the multitudinous efforts and anxieties which go to constitute both the foundation and the structure. The development of a foundry is to a very large extent relative to compliance with its periodical requirements, consequent upon an essential policy of competitive adaptation. It is intended in these notes to review the growth of the brass founding industry in Barrow. Previous to the early 'seventies, brass founding was practically unknown in Barrow. Its industrial birth synchronised with the commencement of operations by the Barrow Iron and Steel Shipbuilding Company about the year 1871, *i.e.*, nearly fifty years ago. The brass foundry then consisted of a small and very badly ventilated shop, the dimensions of which were about 120 ft. by 30 ft. Twelve crucible fires were contained, and one reverberatory furnace of 5 tons melting capacity, with a total output of 5 tons per week. In 1897 the Vickers firm took over the control of the works, and work of every description was undertaken.

Loose Pattern Moulding.—The method of moulding mostly in vogue at that time was what is known as "loose pattern." The elementary nature of the shop tackle made an entire overhaul in that direction necessary, so that an increased output might be expected. Loose pattern moulding may be divided into two classes, viz., moulds made in "dry sand" and in "green sand." The former, generally used in connection with castings of heavier design, receive stove treatment, which renders the impress of the mould impervious to the metal and other pressures due to the casting operation; also the castings are expected to machine out well, and in many cases to withstand a high-water test pressure. "Green sand" moulds are made in specially-prepared sand. Patterns of thin section, and therefore of not much weight in the casting, may be made by this method without having to be stoved at all, as direct contact between the smaller volume of molten metal and the walls of the mould produces no damaging results. Whilst loose pattern work of either of the types to which reference has just been made was at that time the general method of procedure, it will be understood that on the one hand, stoving the mould was costly and occupied valuable time, whilst on the other hand the suitability of light work only for "green sand" was a handicap. The manufacture of a loose pattern often entails a lot of building up in segments to make it rigid and durable for subsequent foundry treatment—this also increasing the cost. It was therefore necessary to reorganise loose pattern moulding from the manipulative standpoint if increased output was to be obtained. By this means, then, there came into operation here the practice of moulding on plates.

Plate Moulding.—This has proved to be a most economical method, even where there is not any lengthened period of repetition work; patterns with quite a limited number required from them can be profitably put on plates, and economies effected, both in pattern shop and foundry. The system has been applied here to such an extended degree that there are now 20,000 mounted for the brass foundry alone. When the patterns are assembled on the plate ready for securing, the foundry foreman decides the position of the gates, runners and risers. The patterns, gates, &c., are then securely fastened on the board or plate, and if any further instructions are necessary for the guidance of the workman they are usually typed on the plates, thereby ensuring a continuancy of the method established, no matter to which moulder the work may at any future time be entrusted. Moreover, in many cases, only one-half of a pattern need be made and mounted on the plate, as this can be set with such accuracy that both bottom and top halves of the mould can be made from it. The practice in the foundry is to have all the moulding boxes drilled to jig, so that the boxes in their own class may be interchangeable. These boxes, made in various sizes, are assigned a special denomination to distinguish them from each other, and the same denomination is engraved upon the plates, so that they can be readily recognised. When in the hands of the moulder, he may probably ram up a dozen bottom parts before he starts with the tops, all the time only using one set of guide pins, dropping them through the slots in the moulding-box into the holes in the plate, thus keeping them in relation with each other until the box is rammed up and the plate withdrawn from the box. The same process is adopted when placing the top half of the mould on the bottom half. As there are only four-thousandths clearance on the pins, it will readily be understood how accurately the parts must register when placed together. The castings are a faithful representation of the pattern, correct in every detail, and production is enormously accelerated. The production is, of course, quite dependent upon the assistance of all concerned, before, during, and after the actual manufacture of the casting by the moulder.

Sectional Departments.—There are sectional departments at Barrow—*e.g.*, for pattern receiving, book-keeping or identification, moulding (referred to), core-making, metal mixing and melting, dressing or fettling, sand-blasting and, lastly, despatch. Each of these sectional departments is as perfectly organised as possible and takes its separate part in the scheme of increase, with the head foreman's office as the governing body, and with a prescribed area of the shop floor upon which to operate.

Foundry Procedure.—If we follow a loose pattern from the moment it reaches the foundry until the casting is despatched to the machine shop, it will be both explanatory and instructive. In the receiving department a complete record of the details of the pattern is made. If no core is required in the moulding, the pattern is immediately taken into the foundry to go in hand in due course. Should cores be required, however, the core-box is put into the hands of the foreman coremaker. We will assume then, that the pattern is one for which cores are necessary, and that the core-box has reached its destination. The foreman moulder sees the pattern, and decides whether it shall be made in "dry" or "green sand." In order to follow a pattern offering the furthest insight into the method of procedure, we will assume that the pattern under consideration is to be treated in "dry sand," and has been therefore handed to a moulder used to that type of work. Some men excel in "dry," others in "green sand" work, and, in their respective positions, produce good results; otherwise, results are frequently disappointing, though it must in fairness be said that there are many men both good and reliable on both classes of work.

The "dry-sand" moulder to whom our pattern has been given, takes the order ticket from it, to enable the card-writer to make out and give him his card for the job, preparatory to the rate-fixer's visit, regarding the basis time to be given for the work in question. The card-writer at the same time enters the name of the moulder and the date and time of the commencement of the job on to the order ticket; this is then sent to the head foreman's office to be entered in their books for the purpose of official progress. The order ticket bearing the moulder's name is then forwarded from there to the despatch, its receipt at this department intimating that the job is passing through the foundry and may be expected. Meanwhile, the moulder has commenced operations on the pattern, and it will be necessary to assume that an interval has elapsed, that our mould has been made, and is now ready to be lifted on to the stove carriage to go through the drying process. It will be remembered, in connection with the pattern, that the core-box was taken charge of by the foreman coremaker; of this we are reminded by his arrival with a tally or ticket bearing the name of the coremaker who has made the cores, from whom they may be obtained by the moulder when the mould has been drawn from the drying stove, which we at this time will suppose has been done. It is a regulation that each foreman must send in his application for metal on a printed duplicated form, verbal orders not being permissible. The foreman has ordered his metal for the mould in compliance with this; the necessary quantities have been weighed, checked and wheeled to the crucible fires, to be put into the pots for melting and then filling the mould. This has been closed by the moulders so as to be ready at about the same time as the metal. Our mould is eventually cast, and allowed to cool.

Dressing, or Fettling.—Later, the mould is taken asunder, and the casting, after being checked by the overlooker, is transferred to the dressing or fettling shop. The first treatment it receives removes the major portion of any parts of the mould which may still be adhering; the cores are then knocked out, and the risers, gates, &c., are cut off by sawmen.

Sand-Blasting.—Further attention by the dresser and, later, sand-blasting, will finish our casting, ready for handling by those who are mainly concerned in its despatch from the foundry. It might here be remembered that the order ticket for the casting had been forwarded from the head foreman's office to that of despatch, and that its receipt there would intimate the later arrival of our casting. The casting is weighed, the figures entered on the order ticket, and a label on to which the same details have been entered is affixed to the casting after which the order ticket is released for commercial attention where, should the order be completed, it will be retained. From the foregoing, the substance of the procedure traversed by a pattern and, later, casting through the foundry may be obtained, though there are subsidiary details also in connection with its progress not requiring mention here.

We will now give a little consideration to what must be called minor departments connected with the foundry, and whose duty it is to support those sectional departments just referred to during progress. We have metal storing, extraction of metals from foundry waste by washing, sorting of scrap, melting and running into pigs for analysis and later storage, sand and loam mills, gas producers, tackle store and, for general upkeep of foundry material, smithing, drilling and joinering departments. Each of these, sectional and supporting, go to make possible the existence of each other, and therefore have some claim to mention in the general scheme of operations.

Loam-Moulding.—It is now necessary to refer to two other methods of moulding—loam-moulding and moulding in cast-iron chills. Loam-moulding was resorted to on some of the large work of a design suitable for the method, chiefly on account of the avoidance thereby of pattern-making expenses. This will be better understood when it is explained that in the case of large patterns of thin sections—as, say, marine condensers—the mould could be made cheaper in loam by the use of strickle-boards. The "dry-sand" method is preferred on most jobs, the exceptions being those on which the avoided cost of pattern-making is more than equivalent to the extra cost of moulding. It will be gathered, therefore, that loam-moulding has not been much practised in our brass foundry.

Chill-Moulding.—With reference to moulding in chills, this is resorted to for work of cylindrical contour and solid content, to be treated later by the forge people.

Bonus System.—It may be of interest also to note the introduction into the foundry of the premium bonus system, which, to judge by results presently obtained, undoubtedly encouraged production in all departments of the foundry. Its value was and is still considerably enhanced by the intelligent co-operation of rate-fixer and foreman in its application, evidenced by the satisfaction with which the scheme has invariably been received by the workman.

Metal Control.—One of the most important items is that of metal control, which is probably the predominant factor on the successful working of the foundry. Where there is a turnover of many tons per week, the greatest care must be exercised in order to avoid mistakes; and the metals, in whatever form they may be, must be perfectly controlled, not alone in the foundry, but also within the different machine and fitting departments where the castings are sent. In the weighing-out department connected to the foundry all material is weighed under supervision—that is, in addition to the workman whose duty it is to weigh the metal, the weight is also checked by another workman before it is transferred to the foundry. In the foundry there is placed before each crucible fire an iron tray into which each full charge is placed. The trays are there to prevent any portion of one heat being accidentally conveyed into a neighbouring heat and adversely affecting the composition of the alloys.

Scrap.—Scrap metal is not used a second time for the purpose of pouring into moulds; it is collected in the foundry and dressing shop, carefully separated, and placed in its own denomination. It is melted down into heats, each heat being given a registered number, and is subsequently analysed before being released for foundry use. All the high-class alloys or specialities are treated separately, and the scrap melted down to ingot form in plumbago crucibles in coke fires. Not only is the scrap from the various alloys kept separate and distinct in the foundry, but also throughout all the machine departments to where non-ferrous metals are despatched the same great care is exercised in isolating the numerous alloys. No better vindication is necessary of the accuracy in which all scrap metal from the machine shops and foundry is dealt with than the fact that from analytical tests subsequently taken only very slight variations occur from the specified alloys. A list of the alloys in use, each being given a distinguishing mark or letter for purposes of identification, is available containing the physical tests or composition, and copies are filed in drawing offices, pattern shop and foundry. Remarks based on foundry experience were added for the guidance of the drawing office, in order to keep the designer in touch with the metallurgist and enable him to take advantage of any specific properties of a given alloy.

Melting.—During the process of melting the metal in the crucibles, great care is exercised to prevent oxidation, and charcoal is used to cover the metal, whilst a metal foreman is constantly in attendance, working under the personal supervision and instructions of the foundry chemist and metallurgist. Particular care is taken that the immediate area of the fires is kept clean and quite free from all scrap, and each fire-hole is fitted with a large cover, so that the metal is in an enclosed chamber during the melting process. Four of the crucible fires can be attended to by one furnaceman. The careful attention given by the workmen, qualified by efficient supervision, has done much to render the brass foundry as nearly immune as possible from the metal troubles so common to the industry. It has been stated earlier in these notes, that a policy of competitive adaptation is essential to the progress of the foundry. The very apparent truth of this is specially applicable to the practice of moulding by machine, with which subject we will now deal.

Machine-Moulding.—The moulding machine has of late years more than justified its inclusion as a productive unit in the plant of a modern foundry. The necessity for increased production has made it imperative that the foundry should be equipped with machines of the most efficient type. It was at one time considered that their only hope of success lay in the direction of repetition work, but this supposition has now been proved a fallacy. The output of jobbing work treated on the moulding machines in the brass foundry here has been quite 75 per cent. higher than when made on the floor. Much of this success, however, has been brought about by intelligent adaptation. The somewhat hesitative acceptance of the moulding machine as an aid to increased production in reality is its supposed futility in dealing with jobbing work. Yet one might ask, how can it have increased the output of jobbing work by 75 per cent. To explain this an extract has been taken from: "Patent Specification, No. 134,327. Improvements in or relating to moulding or like apparatus.

"This invention relates to moulding machines, the object being to render practicable the inexpensive

* Paper read before the Institute of Metals at their Barrow-in-Furness meeting, September 15, 1920.

machine moulding of single or small numbers of articles.

"According to the present invention there is provided a pattern plate corresponding in size to the maximum size of moulding machine table to be dealt with together with a moulding box which is also of maximum capacity, the parts of the pattern plate being provided with indexing means and being so constructed or arranged that any one or more of a variety of loose patterns can be attached as required at predetermined positions thereon. To this end the pattern plate, which, if desired, may be constituted by the table of the moulding machine, is provided with means for indicating the correct position that each pattern is to occupy thereon, such as a series of openings or perforations, hereinafter termed dowel holes, the said dowel holes preferably having index numbers and being located at predetermined distances apart over the surfaces of the pattern plate. The patterns to be employed with the novel pattern plate may also be provided with means for indicating the correct position which they are to occupy on the pattern plate, such as two or more openings or dowel holes for receiving the dowel pins which secure the patterns in position on the pattern plate, so that by referring to the index numbers on the dowel holes of the pattern, the correct position which each pattern is to occupy on the pattern plate will immediately be indicated."

The patent rights for this patent pattern plate were taken out some time ago by Messrs. Vickers, Limited, of Naval Construction Works, Barrow-in-Furness, and Sir James McKechnie, K.B.E., director of Vickers, Limited. It is fitted to all the moulding machines of the jarring type in the brass foundry here, and its efficacy in dealing with work of a jobbing nature on the machines is plainly evident, even to the uninitiated. Jobs of most intricate workmanship, involving numerous cores, have been successfully made by its agency, and the appearance of both mould and casting could not have been improved upon. The economic principle of all machine tools is mass production, but more especially is this the case with the moulding machine, the profits of which largely depend upon the cost and maintenance of the pattern plate. The invention referred to in the foregoing extract has a distinct bearing on the cost of pattern plates, as it entirely does away with the necessity for their manufacture as far as the moulding machine is concerned. During the European War the demand for production to equip our naval and military forces, and those of our Allies, will not have been forgotten by any of us.

In this brass foundry, at that time, there were being turned out 80 tons of brass castings per week. From August, 1914, to November, 1918, there were despatched 2,000,000 brass castings, some to our own shops here, and an enormous quantity to firms all over the country. The weight of these reached over 16,000 tons, which averages more than 70 tons weekly. Some idea of the proportions of our programme may be realised by the statement that at one period our despatch department handled well over 1,200 castings each day for seven days a week. This was only rendered possible by continuous operations being carried out on the moulding machines installed. We are now able to drop as many patterns on to the plate as will come within the area of the box part, and it is the general practice to fill in any vacant spaces that may be on the plate with a recast where only one is required.

The Foundry.—The architectural design of a workshop has much more to do with its efficiency than is generally supposed. Particularly does this apply to foundries where fumes, smoke and dust are continuously mingling with the atmosphere in which the moulders have to work. It is on that account, therefore, essential that spacious, well-lighted, well-ventilated and lofty buildings should be erected for foundry purposes. The health of the workman is our first consideration when preparing plans for new buildings, as air space, good light, and ventilation are three necessities in the life of the moulder and every other worker in the foundry.

Size of Foundry.—This foundry consists of two bays each 310 ft. long by 45 ft. broad by 40 ft. high; another bay 189 ft. long by 64 ft. broad and 40 ft. in height; a fourth bay 187 ft. long by 32 ft. broad and 28 ft. in height. The atmospheric capacity of the building is approximately 2,000,000 cub. ft. One side of the roofing in each of the main bays is of glass, through which a clear light is obtained. There are also large glass panels in the west side of the foundry, and louvres, running the full length of the several bays, ensure the maintenance of a comparatively pure atmosphere.

Cranes, Electric and Hydraulic.—Moulding operations are served by two overhead electrically-driven cranes, each of 15 tons lifting capacity, and two similarly-operated cranes, one of 10 tons and the other of 5 tons lifting capacity. Erected at suitable positions in the shop are 11 hydraulic jib cranes, each with a lift of 3 tons these are exceptionally suitable for the work they are required to do, as their operating involves no special degree of skill in manipulation, and they can be worked by boys.

Drying Stoves.—Situated at different parts of the foundry are 11 drying stoves, which are heated by producer gas.

Melting Plant.—The metal-melting plant consists of two 7-ton and one 5-ton reverberatory furnaces, and 44 crucible fires, the total capacity being 42 tons per day metal output.

Moulding Boxes.—The range of moulding boxes is most extensive and covers every requirement of the moulding industry. Extensive preparations are at the moment being carried out to take over permanently a space outside the entrance of the foundry for their storage. All requirements by moulders for their usage in the foundry will be served by an overhead travelling crane of exceptionally wide span, which will fully cover the space referred to. It is common knowledge amongst foundrymen that systematic treatment in the direction of shop tackle of every description is absolutely essential in the foundry, it being one of the keynotes of production. In order to afford quick access to pattern plates by the plate moulders, large racks are built up to the shop walls for their systematic storage during any waiting period before or during manufacture. These racks contain numerous plates, and are divided into portions, each holding plates requiring a different method of attention, as, for instance, "dry-sand" or "green-sand" manufacture.

Riddles and Sand Mixers.—Electric riddles and sand-mixing machines are placed within easy access, and workmen are kept busily employed feeding the hopper of the machines, whilst the sand already treated is being removed by the moulders.

Portable Mould Dryers.—Portable mould dryers are also in use to skin dry "green-sand" moulds of heavier nature for castings of extreme urgency, and are of great assistance in that direction.

Crucible Coke-Fired Furnaces.—There are, as already stated, 44 crucible fires of a modified "Carr" type which are operated under good conditions, and which, we believe, have contributed in no small measure to the success we have achieved. They are served by two hydraulic jib cranes each of 5 cwt. lifting power, and each with an arc radius of 30 ft. Plumbago crucibles of 300 lb., 200 lb. and 150 lb. holding capacity are used, and are handled with dexterity by the experienced men in attendance.

Ladles.—Apart from the crucibles, there are ladles of 8 tons, 5 tons and 3 tons, also a number of smaller type.

Ash Washing.—The skimmings from crucibles, ladles, &c., are carefully gathered up and taken to the washing department, whence after separation, they are taken to the reverberatory furnace to be melted, one of the cast pigs from the melt of 5 tons or 7 tons being later drilled for analysis, in order to determine its composition for later use.

Briquetting Scrap.—These furnaces are also charged with briquettes, which are compressed by hydraulic pressure, and which are composed of turnings and borings of every description and form of brass. These borings and turnings, coming from the machine shops, are wheeled to the hopper connected with the machine, and pressed into briquette form in order to facilitate handling in the charging into the melting furnace.

Railway System.—The foundry is well served by the works railway system, having two sets of rails entering the shop. One of these takes the consignments from the despatch department, and the other serves for wood, coke, and metal storage. A line also runs parallel the whole length of the foundry, in connection with sand deposits, scrap bins, pig beds, &c. The pig-running beds are situated outside the building, thus keeping the heat, fumes, steam, &c., away from the shop. A special portion is set apart for the white metal plant for the filling of bearings, and all such natures of repair to the works plant.

Chemical Control.—So far as the production of metal is concerned, which includes the making of all the alloys used and the supervision of the subsequent melting for casting purposes, this is all controlled from the chemical laboratory. The chief chemist and metallurgist also advises upon all purchases of raw material. He has control of the melting and mixing of all metals and their heat treatment, as well as of the physical and chemical tests to which the finished products are subjected. The system applies to all foundries—steel, iron, brass, bronze, aluminium, &c.—in each case the man in charge of the melting and mixing is a trained metallurgist on the chief chemist's staff. Work of an experimental nature is constantly in operation and has resulted in the production of a number of special alloys, suitable for numerous purposes. Amongst these may be mentioned what are now known as "high-strength brasses," but which were formerly called "manganese bronzes," upon which Messrs. Vickers were one of the first to experiment. These experiments led to the production of a "high-strength brass" that was stronger and more able to resist corrosion than most other similar bronzes on the market. This was a "high-strength brass" of the 60 : 40 type containing 2 per cent. of nickel and about 3 per cent. of manganese. The tests from sand castings gave 15 tons per square inch yield, 32 tons to 36 tons per square inch tensile, with not less than 15 per cent. elongation on 2 in. This material was somewhat pale in colour, however, which was the cause of further experiments being made to produce a bronze of richer tone. Although this was successfully accomplished, it became increasingly difficult to meet the Government demands for higher strength and yield-point without resorting to artificial cooling of the test-bar. Recognising that such tests did not represent any portion of the casting, other mixtures were experimented with until one was obtained which fulfilled all the Admiralty requirements from a bar cut from any part of the casting. There is now no difficulty in obtaining from such a casting 20 tons per square inch yield, 40 tons per square inch ultimate tensile, and 20 per cent. elongation on 2 in.

Another special alloy that was manufactured here for many years is known as "Vickers Crown Metal," which has the appearance of German silver, and has been found of great value in cases where resistance to corrosion was essential. This also has a yield of 20 tons per square inch, an ultimate tensile of not less than 35 tons per square inch, with about 10 per cent. elongation on 2 in. This has proved of the utmost service for many parts of submarines and their engine fittings. Much experimental work has also been done on white bearing-metals, and a number of white bearing-metal troubles experienced by some of His Majesty's ships whilst on service have been investigated and overcome. It will be of interest here to record generally that the results of such investigations and the conclusions arrived at, which have proved to have been correct in subsequent practice, have been corroborated by the exertions of other workers who have been good enough to publish their results in the Proceedings of this Institute. A large amount of experimental work has also been done on aluminium alloys suitable for pistons for internal combustion engines. For many years, castings of an aluminium-zinc alloy have been made, giving resistance to tensile stress of about 20 tons per square inch, but with practically no elongation. Such castings have in many cases replaced cast iron ones with advantage. A large number of aluminium alloy castings have also been produced during the war to Air Board and other Government specifications. In all such operations, the control of pouring temperatures has been of the utmost service, and our experience has again corroborated the results that have been obtained by the Institute's investigators, who have published their results.

It will thus be seen that every endeavour has been made to work the foundry under scientific control, and it is satisfactory to be able to record how interdependent theory and practice have proved to be and how well theoretical investigations have been borne out in practice. This is as it should be. If theory, as applied to practice, is not borne out, there is something radically wrong with either the theory or the practice. Many members will know that the alloy known as "duralumin" was first investigated at Barrow in this country, and its production has been of great service in the aeronautical world. A few figures regarding the quantity of castings made during the five years covering the war period may be of interest.

Total output of castings from brass foundry	16,886 tons.
Largest casting	23 tons 10 cwt.
Smallest casting	1 oz.
Total average of rejections for the five years	3 per cent.

When it is considered that the whole of these castings have been made to Government specifications, and in numerous cases, in addition to the ordinary physical tests, have had to withstand high-water pressure tests, and also in many cases have required to be machined all over without showing any visible defects, it will, we think, be conceded that the above figures constitute the best proof available indicating the success that has attended the system adopted.

In conclusion, the author would express his indebtedness to Mr. W. Machin and Mr. J. Parker respectively, superintendent and chief foreman of the brass foundry here, for much of the information herein recorded. Also to Sir James McKechnie for his permission, enabling these notes to be placed before the Institute, with the hope that they may prove of service to those members who are chiefly interested in practical foundry work.

THE INFLUENCE OF GASES ON HIGH-GRADE BRASS.*

By T. G. BAMFORD, M.Sc., Member (Birmingham), and W. E. BALLARD, Member (Birmingham).

THE whole of the work recorded in this paper has been carried out under the honorary direction of Professor T. Turner, M.Sc., A.R.S.M., F.I.C., and is published with the consent of the Brass and Copper Tube Association.

Men of long experience in the art of casting high-grade brass seem convinced that defects such as spills sometimes originate from gaseous blowholes in the castings. On the other hand, equally experienced opinion inclines to the view that blowholes are generally very small, and are completely welded up during subsequent work. A Birmingham works' manager is of the opinion that it is more difficult to obtain sound castings from gas-fired than coke-fired furnaces on account of the action of coal-gas combustion products. That pouring temperatures also have a vital influence is a fact beyond dispute, but expert opinion is at variance as to what are the correct temperature ranges.

From earlier work by other experimentalists (named by the authors) it is seen that gaseous inclusions are largely held responsible for faulty brass castings, and at first it was thought that a direct examination of sound and of porous castings, with a view to comparative estimation of the gases contained in the alloys, would be the most profitable line of procedure. Certain work along these lines was undertaken, but was discarded for the following reasons: (1) The results, to be of value, must record the total quantity of gas contained. Reduction of atmospheric pressure above the surface of the metal at normal temperatures caused irregular evolutions of gas, and as all the established methods for determining gases in metals presuppose a complete retention of all gas under such conditions, an entirely new method would have to be devised. (2) The process involved in the evacuation introduces serious practical difficulties when working with brass, owing to the volatility of zinc. The only alternative process which occurred to the authors was by passing a large quantity of neutral gas over molten brass. This would, probably, remove gas contained in the alloy, but its correct estimation would be difficult on account of the comparatively large percentage of neutral gas in the resulting mixture.

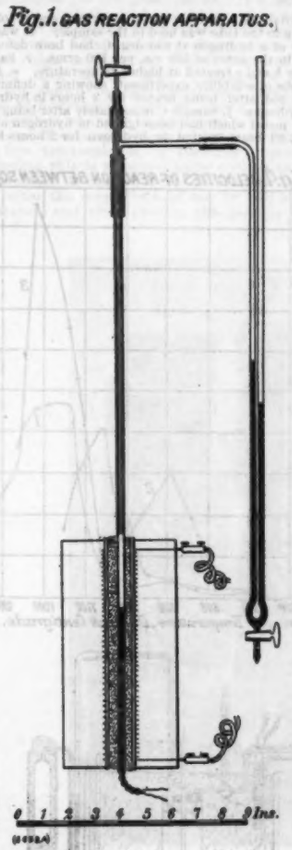
For these reasons it was felt that reliable data could

* Abstract of a paper read before the Institute of Metals, at Barrow-in-Furness, on September 15.

best be obtained by analyses of furnace atmospheres and an examination of the reactions which take place between various constituent gases and high-grade brass.

Samples of gas were taken from points near the top of a plumbago pot heated in a coke-fired crucible furnace. Analyses were carried out of gases drawn from the furnace at different stages of burning through. In all cases the gases over the crucible contained an excess of oxygen, and also small quantities of carbon monoxide ranging from 0·5 per cent. to 0·9 per cent. In one case, that in which the fire had burned down badly and had been recoked for 10 minutes, 1·3 per cent. of hydrogen was found to be present. In no case was there more than a trace of sulphur dioxide, but this is clearly a condition dependent upon the character of the coke used, since when the coke contains volatile sulphur the products of combustion must contain sulphur dioxide. The action of sulphur dioxide on brass was first studied. The brass was heated in a porcelain boat contained in a porcelain combustion tube. The whole was heated in a Heraeous furnace. The temperature was measured with a platinum-platinum-rhodium couple and a direct reading indicator. Dry sulphur dioxide was conducted

Fig. 1. GAS REACTION APPARATUS.



over the sample from the commencement of heating and continuously, until cool again. The sample was taken up to 975 deg. C., kept at that temperature for 10 minutes, and then allowed to cool. The entire operation took about 4 hours. The brass had not melted during the operation, but had a very dark grey appearance, which extended in most places through a cross-section revealed by fracturing a portion. In spots the reddish metal was visible, indicating that the residuum of brass not combined with oxygen or sulphur was, certainly, dezincified. A 10 per cent. increase in weight had taken place as a result of the reaction. A small portion of dark greyish black substance had also sublimed on the cold portion of the combustion tube. The scales (both those remaining in the tube and also the sublimate) were soluble in 40 per cent. hydrochloric acid and evolved H_2S on solution. The solution contained zinc and copper. The composition of the scale formed by the action of $S\,O_2$ on brass is given in Table I.

TABLE I.—*Scale obtained by heating brass (containing copper 70·58 per cent., zinc 28·42 per cent., tin 1·0 per cent.) in sulphur dioxide.*

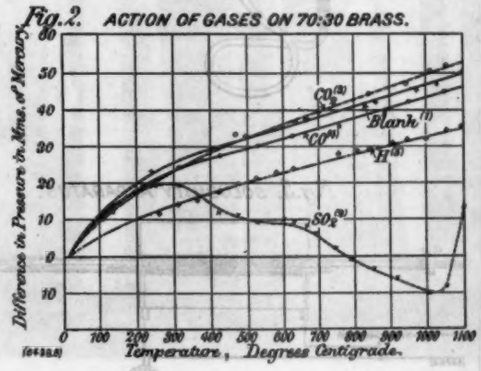
	650 Deg. C. to 850 Deg. C. for 3 Hours.	Up to 1300 Deg. C. 1 Hour.
	per cent.	per cent.
Zinc	41·74	37·40
Copper	35·23	37·70
Sulphur	9·66	9·07
Tin	trace	trace
Sulphates	nil	nil
Difference (largely oxygen)	13·37	15·83

Evidently a marked chemical reaction takes place between sulphur dioxide and brass at temperatures below 1000 deg. C.

A simple apparatus was devised with which to obtain some definite data regarding this chemical reaction. This apparatus is shown in Fig. 1, and consists of a transparent silica tube, packed, together with a thermocouple, in a small resistance furnace. This tube, which contained about 7 grammes of the brass under test, is so arranged that it can be easily filled with pure dry gas, and is also in direct connection with a long U-tube containing mercury, which acts as a pressure gauge. The tube is filled with pure gas in the cold, and the level of the mercury in the limbs of the U-tube is equalised, the pressure inside the apparatus then being equal to one atmosphere. The reaction tube is slowly warmed at an equal rate, and the differences in pressure caused by the expansion or contraction of the gas can readily be observed by measuring the difference in height of the columns of mercury. These differences can be plotted against the temperature indicated by the pyrometer. If these observations were taken without introducing any brass into the reaction tube, the tube being filled with a nearly perfect gas, such as hydrogen and carbon dioxide, or a mixture of nearly perfect gases, such as air, and the results graphed, a smooth curve would be obtained, as the gas would expand according to Charles' law. Also, if brass were introduced and the atmosphere were neutral, as was found to be the case with nitrogen, a similar curve would be obtained. If the gases were absorbed regularly, the values would be lower, although the curve would still retain its original form. If, however, a reaction took place, the form of the curve would change markedly at the temperature at which it occurred.

The curves are shown in Fig. 2. Curve 1 shows the results of a blank experiment in which no brass was enclosed in the tube, and the gaseous atmosphere was air. Curve 2 shows the results obtained using a small rod of brass, made with electro copper and zinc, and containing 70·35 per cent. copper. The gas used was pure dry sulphur dioxide. It will be seen that at about 300 deg. C. rapid absorption commences and continues until 1020 deg. C., at which temperature absorption ceases and an evolution of gas commences, which becomes more rapid up to 1100 deg. C. The brass, remaining after the experiment, had partly been shot up the tube to a height of 2 in. It was noted that there was a brown deposit, and the remaining metal contained 83·65 per cent. copper, showing that considerable dezincification had occurred. This latter also contained one or two large blowholes. A similar piece of brass was melted in an open silica tube of the same diameter as that used in the previous experiment. Its surface was covered with a few grains of charcoal. On cooling it solidified without showing any blowholes. Experiments with sulphur dioxide were also carried out, using electrolytic zinc, and also brass containing 58·70 per cent. copper. In both cases absorption progressed rapidly from 300 deg. C. to 1100 deg. C. An experiment with 70 : 30 brass and sulphuretted hydrogen gave unsatisfactory results, as sulphur was deposited and the curve was erratic. Experiments to determine the reaction of various other gases with brass were undertaken in the same apparatus as that referred to already, in connection with sulphur dioxide. Curve 3 refers to carbon dioxide, which behaves almost as a neutral gas. Curve 4 refers to carbon monoxide, and seems to indicate a small regular absorption. Curve 5 refers to hydrogen, and indicates a fairly large regular absorption.

Fig. 2. ACTION OF GASES ON 70:30 BRASS.



It was impossible to obtain two similar curves with methane, as complex reactions occur, carbon being deposited. It is uncertain which of these reactions are caused by the brass and which are due to thermal dissociation of the methane.

The results recorded show that a very marked reaction occurs between sulphur dioxide and brass. It was therefore thought advisable to endeavour to obtain some figures as to the rapidity with which this reaction takes place at various temperatures.

The apparatus is shown in Fig. 3. It consists of a silica tube about 2 ft. long by $\frac{3}{4}$ in. diameter, which contains a porcelain boat in which is placed between 20 grammes and 30 grammes of brass. A thermocouple is inserted near the boat in the tube, and is fused in a glass rod passing through a bung. The tube is enclosed in a resistance furnace. The one end of the reaction tube is connected by a glass capillary tube to a small mercury pressure gauge. The bung at this end is also fitted with a tube to serve as a gas outlet while filling the tube with gas, but which is closed during the experiment. Through a bung, at the other end of the tube, passes a thermocouple and a capillary tube, which is connected to the gas inlet and to the other small mercury gauge. This second gauge enables gas to be taken into the burette and adjusted to atmospheric pressure. Any gas which has to be rejected from the apparatus is taken care of by means of a tap-funnel inserted in dilute potash solution. The bungs were protected from charring effects by means of two small plugs of asbestos wool placed at each end of the silica tube. During the experiment the burette is put into connection with the reaction tube, small changes of pressure are indicated on the gauge at the other end of the tube and the pressure is adjusted to atmospheric by moving the mercury reservoir of the burette. Before taking velocity measurements the temperature must remain constant for 15 minutes at least, to overcome interference from expansion. The time between the readings is taken accurately, and the volume of gas absorbed is measured in the burette. The velocity is expressed in cubic centimetres per minute.

The values for the rates of reaction were plotted against the temperatures, and the curves obtained are shown in Fig. 4. Curve 2.—The brass used in this case was in the form of small pieces cut from 70 : 29 : 1 condenser tube. The barometric pressure during this experiment was comparatively high, being 759·0 mm. Curve 1 represents the results of an experiment when the atmospheric pressure was only 731 mm. This experiment was carried out on the brass used in the preliminary experiments containing 70·30 per cent. copper. Curve 3 shows the rates of reaction when brass containing 58·7 per cent. copper was used. The barometric pressure was 753 mm.

It will be seen that in all cases the rate of the reaction

$$[SO_2 + \text{brass} \rightleftharpoons \text{metallic sulphides and oxides}]$$

(decrease in gaseous volume)

becomes quite marked below 800 deg. C. in the direction from left to right. At a reduced pressure of 10 mm., however, the previous experiments showed that evolution of SO_2 takes place at temperatures above 1,000 deg. C. and the reverse reaction preponderates.

In a heterogeneous system of this nature an increase in pressure of the reacting gas favours the system formed with a decrease in volume, while a reduction of pressure favours the system formed with an increase in volume. An increase in the partial pressure of SO_2 will favour its reaction with brass and conversely. In the case of 70 : 29 : 1 brass, under a gaseous sulphur dioxide pressure of 759 mm., the minimum reaction velocity of 3·1 c.c. per minute takes place at 993 deg. C. In the case of the 70 : 30 metal under 731 mm. a minimum velocity of 1 c.c. per minute takes place at 1,047 deg. C. The alloys are, of course, of slightly different composition, and the temperatures at which these maximum and minimum velocities take place do not synchronise in the two cases. It seems probable, however, that with the small partial pressure of SO_2, which could not be exceeded under furnace conditions, this minimum rate of absorption would be converted into positive evolution. In other words, at temperatures between 950 deg. C. and 1,050 deg. C. sulphur dioxide could not be absorbed by brass in the furnace, but would be actually eliminated from the metal. If this be a fact, it would be important to provide a free egress for the passage of the gas from the metal at this stage. This implies that the metal must be poured at such a temperature as to permit the metal remaining entirely fluid in the mould for a few moments.

Solubility of Hydrogen in Brass.—The results of the reaction between various gases and brass indicate that there is a definite solubility of hydrogen in brass. At 1,150 deg. C. a change in pressure of 22 mm. less than occurred with the blank experiment was observed. This would correspond to an absorption of about 11 milligrammes per 100 grammes of brass. These experiments were, however, comparative, and would be affected by the rate of heating, laboratory temperature, and so forth, and while definite as indicating the broad facts, nevertheless cannot be used as a means of measuring the solubility. Sieverts and Krumbhaar show that solid copper at 1,024 deg. C. absorbs 0·360 milligrammes, and liquid copper at 1,120 deg. C. 0·608 milligrammes of hydrogen per 100 grammes. It would appear that no attempt has been made, prior to the investigations recorded here below, to determine the solubility of hydrogen in brass, as the volatility of the zinc precludes the possibility of evacuation during estimation, which was essentially Sieverts' method. It was decided to endeavour to determine the absolute solubility of hydrogen in brass at temperatures to which the metal is ordinarily subjected in the casting operations. The difficulties confronting an investigation of this nature may be considered under three heads: (1) Preparation of hydrogen-free brass of suitable composition; (2) the bringing of the brass to the desired temperature in a neutral atmosphere, and replacing this latter with an atmosphere of hydrogen without involving heavy zinc losses; (3) the measurement of the weight of the hydrogen absorbed.

1. *Preparation of Hydrogen-Free Brass.*—W. Stahl has shown that carbon dioxide is insoluble in copper, and our experiments also show that carbon dioxide acts as a neutral gas, and it was therefore used as a basis for the preparation of hydrogen-free brass. It was first proposed to pump off the gases, which are probably present in cast brass, by heating in carbon dioxide and subjecting the containing tube to rapid exhaustion, and each time refilling it with the neutral gas. A

sample of cast 60 : 40 brass was heated in a tube, one end of which was fitted with a mica window. When the brass attained the temperature of about 800 deg. C. the tube was evacuated by the use of a Fleuss pump. The small rods of brass formed a mass resembling a honeycomb. If brass were treated in a similar way in a ¼-in. tube, such as is necessary for the solubility experiments, it would certainly break the tube. A different method of preparing hydrogen-free brass had, therefore, to be used. The inflation of the brass was due to rapid distillation of the zinc at 800 deg. C. under reduced pressure. The brass finally used was prepared by melting the metal in an atmosphere of carbon dioxide and bubbling the gas through the metal for about half an hour. The metal was then poured and allowed to cool in the same atmosphere.

2. *Bringing the Brass to the desired Temperature in an Atmosphere of Carbon Dioxide, and then replacing the latter by an atmosphere of hydrogen without involving heavy zinc losses.*—The brass in the form of small strips was heated in a silica tube of ¼ in. inside diameter, filled at the commencement of each test with pure dry carbon dioxide. This tube was placed alongside a similar one in a nichrome-wound resistance furnace, the second tube containing a thermocouple. The spaces in the hot zone of the tube were packed with broken silica, which had been passed through a 30-mesh sieve, the cooler portion being filled with hard glass rod. The free volume was 5·4 c.c. The tube was connected to a large flask, 2430 c.c. capacity, by means of a capillary glass tube and a three-way cock, through which it was filled with pure dry hydrogen. When filling the flask, discharged gases were allowed to pass out through a long tube reaching to the bottom thereof. The hydrogen had therefore to enter the flask at the top and leave it at the bottom, and it was thus possible to ensure the presence of perfectly pure hydrogen in all parts. When this was accomplished, the upper extremity of the tube was sealed off in the blowpipe. When the brass had attained the desired constant temperature, the tube which contained it was connected to the flask by turning the three-way tap, and the process of diffusion commenced between carbon dioxide and hydrogen. The diffusion was facilitated by the frequent withdrawal of 50 c.c. of the hydrogen into a small mercury-filled gas burette, connected to the silica tube at its other end by means of a straight-way cock. The gas drawn off was each time driven back into the burette after a lapse of a few minutes. When diffusion had become complete, the partial pressure of the carbon dioxide would be only 2·2 per cent. of the total gaseous pressure. The partial pressure of the hydrogen would therefore be nearly 98 per cent. of the total, and would not differ by a large value from the normal atmosphere.

3. *Measurement of hydrogen absorbed.*—A compensating bulb consisting of a 50 c.c. pipette was connected to the large flask in order to maintain determinate conditions of gaseous density in the system. The pipette was placed in a vertical position and sealed off at the bottom end. The tube at the other end of the pipette was bent round into a vertical position alongside and parallel with a portion of the long tube, which formed a connection with the large flask. The arrangement is shown in Fig. 5. The flask and compensating bulb were each immersed in damp ice, and in all cases, before taking measurement, the level of mercury in the compensating bulb was adjusted to a fixed mark etched on the vertical portion of the bent tube near the top of the pipette.

TABLE IV.

Reference Letter.	Approximate Time after Exposure to Hydrogen.	Gas used to expel Hydrogen.	Approximate Temperature of Heating. Degrees C.	Time of Heating in Neutral Gas.	Weight of Sample.	Area of Sample.	Weight of H_2O formed.	Hydrogen evolved—c.c. at N.T.P. per Grm. Sample.	Hydrogen evolved—c.c. at N.T.P. per Sq. Cm.
					Grms.	Sq. cm.			
a	1 day	CO_2	550	20 min.	4·3710	5·7	0·0034	0·97	0·74
b	3 days	CO_2	550	20 min.	16·0626	15·5	0·0072	0·56	0·58
c	4 days	CO_2	550	1 hour	16·0626	15·5	nil	nil	nil
d	4 days	CO_2	900	1 hour	16·0626	15·5	nil	nil	nil
e	5 days	CO_2	900	30 min.	5·7800	5·0	0·0016	0·35	0·34
f	5 days	air	900	30 min.	6·9600	7·1	0·0048	0·91	0·78
g	12 hours	air	900	30 min.	30·7598	—	nil	nil	nil
h	1 day	air	900	30 min.	116·0522	36·8	0·0027	0·029	0·09
i	30 min.	air	900	30 min.	116·0522	26·8	0·0006	0·0065	0·02
j	4 hours	CO_2	900	30 min.	116·0522	36·8	nil	nil	nil
k	1 day	air	900	30 min.	—	97·0	0·0013	—	0·016
l	2 hours	O	1100	2 hours	16·5240	16·0	0 0090	0·67	0·7

Description of Samples.

a. Sample of 70 : 30 brass cast in hydrogen. The brass was melted in a crucible under hydrogen, and a cold silica tube ¼ in. dia. dipped in quickly and withdrawn. The pellet remaining in the tube was used in the sample. It was stored in a dry glass tube in a desiccator. *b*. Sample on which solubility of a hydrogen at 855 deg. C. had been determined. Stored in dry tube. The solubility given by the determinations was in the order of 100 c.c. per 100 grms. *c*. Sample *b*, after being stored through the night in a dry tube. *d*. Sample from *b* and *c* treated at higher temperature. *e*. Another portion of original sample *b*, also *f*. *g*. Sample taken straight from tube of solubility experiment, showing a definite solubility of approximately 80 c.c. per 100 grms. *h*. Cast 70 : 30 brass rod after being heated for 3 hours in hydrogen at 800 deg. C. to 900 deg. C. and air cooled. *i*. Sample *h* retreated with hydrogen. *j*. Sample *i*, immediately after being treated in air, was re-ignited in CO_2. *k*. Piece of condenser tube of 70 : 29 : 1 metal which had been ignited in hydrogen at about 950 deg. C. for 1 hour and cooled in hydrogen. *l*. Sample of 70 : 30 brass treated in hydrogen for 2 hours between 800 deg. C. and 900 deg. C.

Fig.3. REACTION VELOCITY APPARATUS.

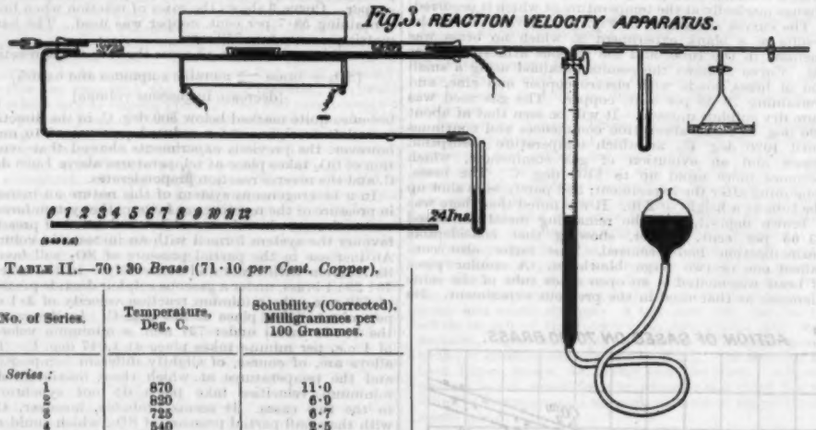


Fig.4. VELOCITIES OF REACTION BETWEEN SO_2 & BRASS.

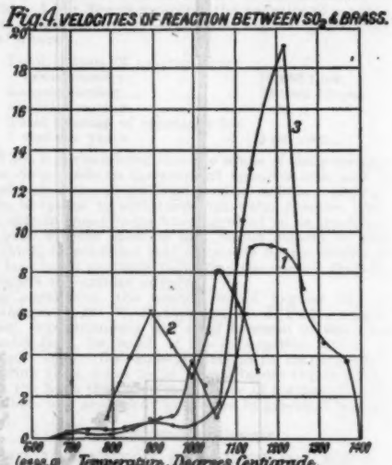


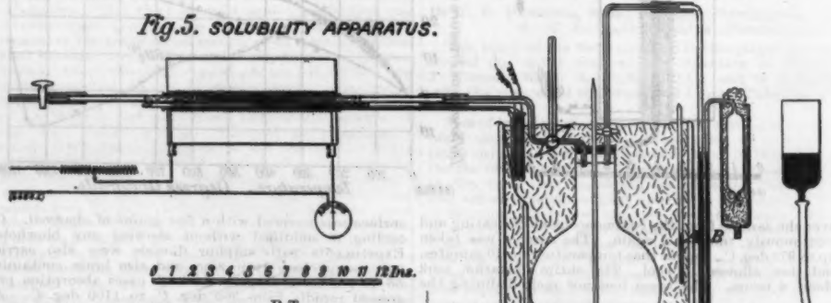
TABLE II.—70 : 30 *Brass* (71·10 *per Cent. Copper*).

No. of Series.	Temperature, Deg. C.	Solubility (Corrected). Milligrammes per 100 Grammes.
1st *Series :*		
1	870	11·0
2	820	6·9
3	725	6·7
4	540	2·5
11	30	nil
2nd *Series :*		
5	850	3·3
6	750	2·7
7	30	nil

TABLE III.—*Brunner Mond Zinc* (*Cast in* CO_2).

No. of Series.	Temperature, Deg. C.	Solubility (Corrected). Milligrammes per 100 Grammes.
8	750	1·3
9	600	3·5
10	300	4·8

Fig.5. SOLUBILITY APPARATUS.



Now, since $p v = R T \quad \therefore p = \frac{R T}{v}$

and since the mass of gas in the compensating bulb remains constant its pressure is a function of its temperature and volume. Experimental conditions were arranged, as already explained, to maintain a constant temperature of the gas within the compensating bulb. The volume of the gas is also brought to a constant value. The pressure of the gas within the compensating bulb is therefore maintained at constant value during the experiments. Now, if p_c be the gaseous pressure within the compensating bulb, and p_a be the gaseous pressure within the large flask, at any given moment, and also if H_c and H_a are the heights of mercury in tubes B and A (Fig. 5) above any fixed point, it follows, from principles of hydrostatics, that when equilibrium is obtained

$$p_a + H_a = p_c + H_c, \text{ or } p_a = p_c + H_c - H_a.$$

As already stated, p_c and H_c are maintained constant during solubility determinations. Any change in p_a will therefore be measured by a change in H_a and equal to it. Any hydrogen that is absorbed will cause a reduction of pressure within the absorption system, which can be measured by noting the change in the level of the mercury in tube A. Since the absorption system has a very large volume compared with the volume of brass under examination, no large change in pressure takes place. A millimetre change in pressure corresponds to about a milligramme of hydrogen absorbed per 100 grammes of brass. We do not, therefore, claim that our results exceed an accuracy of 0·5 milligrammes per 100 grammes of brass.

The notable and important feature which we claim for these experiments is that the solubility determinations are made throughout without subjecting the brass to any gaseous pressures differing by any large amounts from one atmosphere. It might be argued that it would be impossible to maintain the temperature of the gases within the large flask and the compensating bulb sufficiently constant for the purpose of these experiments. Several blank experiments were undertaken in order to test this question, and also to investigate the extent to which the silica tube might permit diffusion of the hydrogen, and introduce errors from this source. The pressure within the absorption system remained quite constant at all temperatures at which the blank experiments were run below 700 deg. C, but at 700 deg. C. a change in pressure occurred which would have corresponded to a solubility of 0·3 milligrammes of hydrogen

per 100 grammes of brass. At 800 deg. C. the same figure was obtained, but at 900 deg. C. the figure rose to 0·7 milligrammes per 100 grammes, and at 1000 deg. C. as high as 7 milligrammes. That these results were due to the character of the silica permitting the passage of hydrogen through it at high temperatures was confirmed by subjecting the silica tube to a gaseous pressure of 75 mm. of mercury. After half an hour at 950 deg. C. the pressure fell 2 mm. After half an hour at 980 deg. C. it fell an additional 3 mm., and after a quarter of an hour at 1010 deg. C. it fell an additional 14 mm.. to a pressure of 56 mm. Evidently at 1000 deg. C. the silica was unsuitable for taking solubility experiments, but below 900 deg. C. suitable corrections could be made within the limits of experimental error.

In the results first shown solubility determinations were all made less than eight days after the samples had been actually cast. In the second series the samples from the ingots used in observations 2, 3, and 4 were left for thirty days before solubilities were taken.

The results obtained are shown in Table II.

It will be remembered that Sieverts' results showed a very small solubility for hydrogen in copper, merely 0·3 milligrammes for 100 grammes at 919 deg. C., and it was thought that the high solubility of hydrogen in brass might be accounted for by the high solubility of hydrogen in zinc. Experimental observations did not reveal such high solubilities, and if Sieverts' results are correct, then 70 : 30 brass possesses a physical property not shown by the constituent metals. The solubilities of hydrogen in zinc are shown in Table III. The same method was used as for brass.

Since brass absorbs such large quantities of hydrogen at quite low temperatures, it becomes important to decide whether this is removed upon cooling in the air or after passage of neutral gas. The silica tube was sealed off after the completion of one or two solubility determinations, and after cooling, the gaseous pressure

TABLE V.—BILLET CASTING EXPERIMENTS.

Reference No.	Flux.	Furnace Temperature. Deg. C.	Casting Temperature. Deg. C.	Analysis. Copper per Cent.	Tin per Cent.	Lead per Cent.	Iron per Cent.	Tensile Strength Tons per Sq. In.	Elongation per Cent. on 2 in. Approximate Diameter of all Tests = 0·8 In.	Remarks.
21B	Boric acid	1150	1130	Split for visual examination.						Fracture fairly good. Tests split longitudinally.
22B	Boric acid	1150	1050							Fracture fairly good.
23B	Boric acid	1150	970							Fracture full of holes.
24B	Boric acid	1130	1125					14·06	16	
25B	Boric acid	1130	1050	71·95	0·86	0·48	0·16	13·26	23	8 minutes from furnace to last pouring.
26B	Boric acid	1130	970					6·67	12	
27B	Boric acid	above	1230					16·43	45	
28B	Boric acid	1230 for 5 min.	1050	76·69	1·12	—	0·06	16·06	40	
29B	Boric acid		970					8·97	19	
30B	Boric acid	1145	1040					14·01	21	
31B	Boric acid	1145	—	69·30	1·10	—	0·05	13·21	19	The three billets poured rapidly Time, 4·5 minutes.
32B	Boric acid	1145	—					14·21	20	
33B	Boric acid	1085	1080					14·52	17	
34B	Boric acid	1085	1030	69·50	1·04	0·38	0·02	12·16	13	30 per cent. of 70 : 29 : 1 tube scrap added to the charge.
35B	Boric acid	1085	970					8·87	9	
36B	Boric acid	1130 for 1 min.	1125					13·35	25	
37B	Boric acid		1040	70·11	0·75	—	0·01	9·37	13	
38B	Boric acid		965					5·92	10	
39B	Boric acid	1115	1110					22·67	24	Broke near shoulder.
40B	Boric acid	1115	1050	60·24	—	—	0·52	22·18	23	Broke near shoulder.
41B	Boric acid	1115	960					22·42	23	Broke near shoulder.
42B	Charcoal	1035	1030					22·68	36	The three billets poured rapidly.
43B	Charcoal	1035	—	60·70	—	—	0·06	23·69	29	Broke near shoulder
44B	Charcoal	1035	—					23·49	29	Broke near shoulder (Time, 3 minutes.)
45B	Charcoal	1130 for 15 min.	1130					23·29	29	
46B	Charcoal		1050	60·70	—	0·84	0·24	24·06	36	
47B	Charcoal		970					20·70	20	

FIG. 6. Split Solid Brass Billets.
(Note holes in No. 23.)

within the tube did not increase. It is clear that after cooling in a closed atmosphere of hydrogen no marked quantity was evolved in this particular instance.

Immediately after the solubility determinations on sample 4 had been made, it was treated with a current of of carbon dioxide at 600 deg. C. for 60 minutes. The solubility was then taken at 680 deg. C., and showed 1·8 milligrammes per 100 grammes. The sample was then treated in a current of carbon dioxide at 800 deg. C. for sixty minutes. The solubility at 540 deg. C. afterwards was 1·2 milligrammes per 100 grammes. After further treatment at 900 deg. C. for 60 minutes, a solubility of 2·4 milligrammes at 540 deg. C. was obtained. Finally, the sample was treated in carbon dioxide at 900 deg. C. for 30 minutes, and the solubility taken at 740 deg. C. was 2·7 milligrammes per 100 grammes. Apparently, treatment in carbon dioxide at 600 deg. C. removes a portion of the hydrogen, and treatment at 900 deg. C. may remove the major portion. Direct experiments were undertaken to clear up this matter. It was decided to ignite weighed samples of brass in a stream of dry carbon dioxide, and to oxidise any hydrogen, in the sample, by passing over heated cupric oxide. The water thus formed was observed in tared drying tubes. As the quantity of water to be weighed was very small, extremely careful manipulation was necessary. Thus it was absolutely essential that the tared tube should not be touched directly with the skin, and as forceps are awkward when used with a U-tube, a silk handkerchief was used to hold the tube. It frequently took several hours to dry the apparatus completely, and in all experiments, the results of which are given, at least two successful blanks were obtained immediately before and after the experiments. By successful blank experiments are meant experiments in which all the conditions requisite for a determination are carried out, but there is no brass in the tube, and the tared tube shows no increase in weight. The results obtained are shown in Table IV.

It would appear that a large proportion of the hydrogen retained in brass in the cold solid state is easily removed by heating at 550 deg. C. for a short time in a stream of carbon dioxide, and that this gas is more effective in removing it than air, and direct melting and complete oxidation in oxygen (*l*) does not remove larger quantities. That the area of the samples is a factor in the retention and rejection of hydrogen seems probable, but that this is not the only factor is shown by the varying values for the amount of hydrogen obtained per sq. cm. of surface. The nature of the surface also seems to play an important part, as it was noticed that roughened or oxidised surfaces do not give up hydrogen readily. For instance, experiment *i* was conducted on the sample used and oxidised in experiment *h*, subsequently heated in hydrogen. The sample therefore used for *i* had a surface coated with a roughened film of copper-rich material, due to the reduction of the oxide layer formed in *h*, and the volatilisation of the finely divided zinc produced. The values for *i* are much lower than those for *h*, and subsequently treatment in CO_2 gave no further increase. It is interesting to note that sample *b* gave a solubility of approximately 100 c.c. per 100 grammes in the solubility apparatus, while it only gave out on the average of three samples, *b*, *e*, and *f*, 61 c.c. per 100 grammes, but had apparently rejected it all on cooling, as it gave no increase.

The conclusions regarding the solubility of hydrogen in brass are: (1) Hydrogen dissolves in 70 : 30 brass in very large quantities between 500 deg. C. and 900 deg. C.; (2) the quantity absorbed is not a mere function of temperature and pressure, but is affected by the character and dimensions of the surface; (3) the major portion of the hydrogen absorbed is usually retained on cooling; (4) large quantities of the hydrogen retained may be removed by treatment with a neutral gas at 600 deg. C. or above.

Since brass will withdraw from an enclosing environment of hydrogen considerable amounts of this gas, it follows that brass can either absorb large quantities on its surface, or that large quantities can actually pass into the metal. In the former case, clearly, such absorbed gas could not be responsible for internal unsoundness, and in the latter case, since the hydrogen could diffuse through the metal, it could hardly develop sufficient internal pressure to be responsible for blowholes. As we have shown, however, such an argument does not apply in the case of sulphur dioxide, in the presence of which it seems probable that an unsuitable pouring temperature might be responsible for unsoundness. Investigation was therefore carried out on the relationship existing

TABLE VI.—TUBE CASTING EXPERIMENTS. CLASSIFICATION ACCORDING TO HEATS.

Reference No.	Casting Temperature. Deg. C.	Top of Tube (A). Break. Tons per Sq. In.	Top of Tube (A). Elongation. per Cent. on 2 In.	Remarks on Fracture.	Middle of Tube (B). Break. Tons per Sq. In.	Middle of Tube (B). Elongation per Cent. on 2 In.	Remarks on Fracture.	Bottom of Tube (C). Break. Tons per Sq. In.	Bottom of Tube (C). Elongation per Cent. on 2 In.	Remarks on Fracture.
1	1175	13·44	9	Good	13·58	9	Good.. ..	16·46	13	Good
2	1135	14·94	13	Good	13·73	7	Good	13·33	7	Good (broke in shoulder)
3	1090	14·05	8	Two large holes	12·21	6	Few large holes	12·21	7	Large holes
4	1215	14·13	12	Good	13·87	9	Good	14·13	11	Good
5	1150	13·61	6	Some large holes	15·15	12	Few large holes	14·83	15	Good
6	1090	14·42	9	Small holes ..	13·26	6	Broke in shoulder } Large holes }	12·43	7	Large holes
7	1135	12·96	8	Many small holes	14·10	8	Small holes ..	13·01	6	Good
8	1110	13·22	6	Many small holes	12·26	6	Small holes (broke in shoulder) }	13·99	10	Good
9 (0)	Below 1100	13·37	8	Large holes ..	14·05	9	Fairly good, but open grain	13·82	8	Good

Reference No.	Composition. Copper per Cent.	Tin per Cent.	Lead per Cent.	Iron per Cent.
1	—	—	—	—
2	70·5	1·02	0·40	0·13
3	—	—	—	—
4	—	—	—	—
5	70·9	1·00	0·40	0·08
6	—	—	—	—
7	—	—	—	—
8	70·9	0·97	0·40	0·10
9 (0)	—	—	—	—

data relating to the tests is given in Table V. The billets from one heat were split for visual examination. All had fair surfaces, but while those poured at 1,050 deg. C. and at 1,130 deg. C. appeared quite sound, that one poured at 970 deg. C. was honeycombed with large holes of a dark colour (Fig. 6, No. 23).

The work in connection with brass tubes was carried out in 70 : 29 : 1 metal. The charges weighed approximately 160 lb., and consisted of

D.R.W. electro-ingot copper—oxygen = 0·115 per cent.
M.M.C. spelter—lead = 1·77 per cent.
Tin.
30 per cent. of 70 : 29 : 1 tube scrap.

The heats were melted in plumbago pots in coke fires under a flux, which consisted largely of sodium carbonate and aluminium flouride. Each heat made four tubes 2¾ in. external diameter by ⅛ in. thick, and weighing approximately 30 lb. The cores were similar to those in ordinary works routine, and the mould dressing consisted of a light smear of tar with fine charcoal dusted on.

TABLE VII.—TUBE CASTING EXPERIMENTS. CLASSIFICATION ACCORDING TO CASTING TEMPERATURE.

Reference No.	Casting Temperature. Deg. C.	Top of Tube (A). Break Tons per Sq. In.	Top of Tube (A). Elongation. per Cent. on 2 In.	Remarks on Fracture.	Middle of Tube (B). Break Tons per Sq. In.	Middle of Tube (B). Elongation per Cent. on 2 In.	Remarks on Fracture.	Bottom of Tube (C). Break Tons per Sq. In.	Bottom of Tube (C). Elongation per Cent. on 2 In.	Remarks on Fracture.
4	1215	14·13	12	Good	13·87	9	Good	14·13	11	Good
1	1175	13·44	9	Good	13·58	9	Good	16·46	13	Good
5	1150	13·61	6	Some large holes	15·15	12	Few large holes	14·83	15	Good
2	1135	14·94	13	Good	13·75	7	Good	13·33	7	Good (broke in shoulder)
7	1135	12·96	8	Small holes ..	14·10	8	Small holes ..	13·01	6	Good
8	1110	13·22	6	Small holes ..	12·26	6	Small holes (broke in shoulder) }	13·99	10	Good
9 (0)	Below 1100	13·37	8	Large holes ..	14·05	9	Fairly good ..	13·82	8	Good
3	1090	14·05	8	Two large holes	12·21	6	Few large holes	12·21	7	Large holes
6	1090	14·42	9	Small holes ..	13·26	6	Large holes (broke in shoulder)	12·43	7	Large holes

Reference No.	Composition. Copper per Cent.	Tin per Cent.	Lead per Cent.	Iron per Cent.
4	70·9	1·00	0·40	0·08
1	70·5	1·02	0·40	0·13
5	70·9	1·00	0·40	0·08
2	70·5	1·02	0·40	0·13
7	70·9	0·97	0·40	0·10
8	70·9	0·97	0·40	0·10
9 (0)	70·9	0·97	0·40	0·10
3	70·5	1·02	0·40	0·13
6	70·9	1·00	0·40	0·08

Two tubes were poured first, and then the temperature of the remaining metal was taken immediately before each of the last two tubes were cast. Tests were carried out on the first, third and fourth tubes of each heat. Three heats were cast, the maximum temperatures of each heat being different. It was difficult to decide from which portion of the tube the tensile test-piece should be cut, and in order to clear up this point, after the gates of the tube had been cut off, each casting was divided equally into three parts, namely, a top, middle, and bottom portion. A test-piece was cut from each of these parts on the side opposite to the gate. Especial notice was taken of the fractures of the tensile pieces, so that any porosity might be detected.

The results are set out in the accompanying tables. Table VI shows them in the order as cast. Tubes 1, 2, 3, are from the first heat; 4, 5, 6, from the second; and 7, 8, 9, from the third. Table VII shows the results set in order of casting temperature. The sheath of the pyrometer collapsed while taking the temperature of the metal for tube 9, so that the exact temperature could not be ascertained. The remarks on the fracture indicate only the absence or presence of holes, and are no indication as to the grain of the metal. For instance, the fracture of the middle part of No. 5 indicated a much stronger metal than the middle part of No. 9 which, although free from holes, had an exceedingly open grain.

The conclusions drawn are: (1) In ordinary foundry practice, using a coke-fired natural draught wind furnace, it is impossible to impair seriously the mechanical properties of the casting by overheating. (2) Cooling the metal to within 40 deg. C. of the liquidus will certainly ruin the mechanical properties of high-grade brass which has been melted in ordinary furnace atmospheres, and will probably render the casting porous. (3) In casting tubes a higher temperature is needed than when casting solid ingots, and it is not advisable to cast 70 : 29 : 1 tubes below 1150 deg. C. (4) Exceptionally prolonged periods of heating of the metal in the furnace do not impair the mechanical properties of the resulting casting, but, of course, are to be deplored for commercial reasons on account of the consequential high zinc losses. (5) The furnace treatment is not a deciding factor in influencing the quality of the casting, but the pouring temperature is the notable factor. (6) Unsoundness is usually confined to the upper portion of a casting.

It may be mentioned as regards the composition of the castings, that samples of analysis were taken respectively from tops, middles and bottoms. The samples from any one heat all showed identical composition within the limit of experimental error. Evidently the relative soundness of the bottoms of the tubes is not a function of metallic composition.

It has been shown that a marked interaction takes place between 70 : 30 brass on the one hand and sulphur dioxide and hydrogen on the other hand. It has also been shown that melting in ordinary furnace atmospheres and pouring at too low a temperature will produce unsound castings. A special type of furnace was designed and obtained from the Morgan Crucible Company, Limited, with the object of obtaining a positive answer to the question as to whether any particular furnace gases would have a deleterious effect upon the quality of brass castings, provided the metal was poured at the correct temperature. We were pleased with the working of the furnace, and interesting results were obtained. When using this furnace the conclusions we have already put forward were borne out, although it may be mentioned that they were formulated before using the furnace. Descriptive details concerning the installation and experimental results obtained with the furnace, are at present on the files of the British Non-Ferrous Metals Research Association. It is hoped that these details will be available for publication at a later date.

An expression of appreciation must be tendered to Professor Turner, who gave freely of his exceptional experience and helpful guidance at all times. Thanks are also due to the members of the Brass and Copper Castings Research Committee, through whose influence the requisite facilities were obtained. Particularly, mention must be made of Muntz's Metal Company, Limited, who offered an open sesame to their works. The thanks of the research workers are also due to Mr. A. G. Barnard, who carried out much of the routine work.

APPENDIX.

METHODS ADOPTED IN THE PREPARATION OF THE VARIOUS GASES USED IN THE LABORATORY EXPERIMENTS.

Carbon Dioxide.—The gas was prepared from marble and hydrochloric acid, and was purified by washing in acid permanganate, passing over yellow phosphorus and washing in lead acetate. It was finally dried by calcium chloride.

Carbon Monoxide.—This gas was prepared by dropping formic acid into warm sulphuric acid. It was washed in caustic potash solution, and dried over calcium chloride.

Hydrogen.—Prepared by the action of dilute sulphuric acid on electrolytic zinc. It was washed in solution of caustic potash, alkaline pyrogallol and silver nitrate, and finally dried over calcium chloride.

Methane (Marsh Gas).—Prepared by dropping methyl iodide on to a zinc-copper couple covered with methyl alcohol. It was freed from volatile bodies by passing up a reflux condenser and washing in potash. The gas was dried over calcium chloride.

Sulphur Dioxide.—This gas was obtained from a syphon of the liquefied gas. It was passed through sulphuric acid to check its rate of flow.

Investigation of the Relationship between the Casting and Pouring Temperature and the Quality of Brass Castings.—Experiments were carried out in connection with solid brass billets and also with brass tubes. The temperature of the metal was in all cases taken with a Cambridge Scientific Instrument Company's portable platinum alloy couple and indicator, and was taken immediately before the pot was lifted from the furnace. This temperature, in some cases, was also taken as the pouring temperature of the first tube or billet, as the error resulting therefrom was found to be no more than 5 deg. C. Billets were cast in 70 : 29 : 1 metal, and also in Munts metal. Three billets were cast from each charge. The moulds were of the cannon type, 25 in. long by 1¾ in. diameter, with a 1/16-in. taper. The dressing used was vaseline made to a thick paste with powdered graphite. The billets weighed approximately 22 lb. C.C.C. electro-ingot copper and M.M.C. zinc were used. Thermal treatment involving all possible ranges from the maximum to the minimum limits of foundry practice were used and melts were run, using both all new metal and also 30 per cent. scrap. The between the casting and pouring temperatures and the qualities of brass casting.

NEW ZEALAND RAILWAY ELECTRIFICATION.—H.M. Trade Commissioner at Wellington, New Zealand, has recently cabled to the Department of Overseas Trade the award of a contract to the English Electric Company for the electrification of a section of the Midland Railway of New Zealand. He adds that special importance is attached to this contract as it was obtained on the merits of the tender in the face of strong American competition. The section to be electrified is known as "Arthur's Pass." It is the connecting link between the Government railway system of the east coast and west coast of South Island. At present the whole of the railways in New Zealand are steam operated, and it is not proposed at present to electrify more than the section covered by this contract. The importance of awarding the first contract to a British firm will therefore be appreciated. The section to be electrified includes a tunnel over 5 miles long and three steel bridges, the rest of the section consisting of earthworks. A great portion of the section is on a grade of 1 to 33 and the summit is about 2,400 ft. above the sea level. Considerable snow falls in some winters, as much as 5 ft. having been experienced. The contract includes the provision of the power plant, the tunnel lighting installation, the overhead transmission line and the complete equipment for the electrical operation of the section of the railway referred to. The system to be used is 1,500 volts direct current overhead contact. The power-house must be at Otira Station, which is 1,260 ft. above sea level, and the power will be generated by geared turbine direct-current sets. The boilers, it is proposed, should be operated on dust fuel in order to utilise the product of a number of local coal mines at which coal is raised which is too fine for ordinary consumption.